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(54) Title of the Invention: **Trenching apparatus and a method of trenching**
Abstract Title: **A trenching apparatus having a winch**

(57) A trenching apparatus featuring a body 10 moveable on the ground surface and a ground engagement boom 12 associated with the body, wherein the ground engagement boom comprises a chain 14 for interacting with earth in use. Lifting means are arranged to control and configure the ground engagement boom so as to enter the ground and to configure the boom to an inclined orientation in which the boom extends at least partially over the body. A winch 80 is provided on the body to engage with the chain of the ground engagement boom when in the inclined orientation. Optionally, the ground engagement boom is a cutting boom or a mixing boom. Optionally, the winch has a spool with a cable having an end connector for engagement with the end of a replacement chain to be put on the ground engagement boom when in the inclined orientation. Optionally, the cable is routed via a shoulder on the distal end of the ground engagement boom to enable substantially the entire length of the ground engagement boom to be surrounded by the replacement chain.

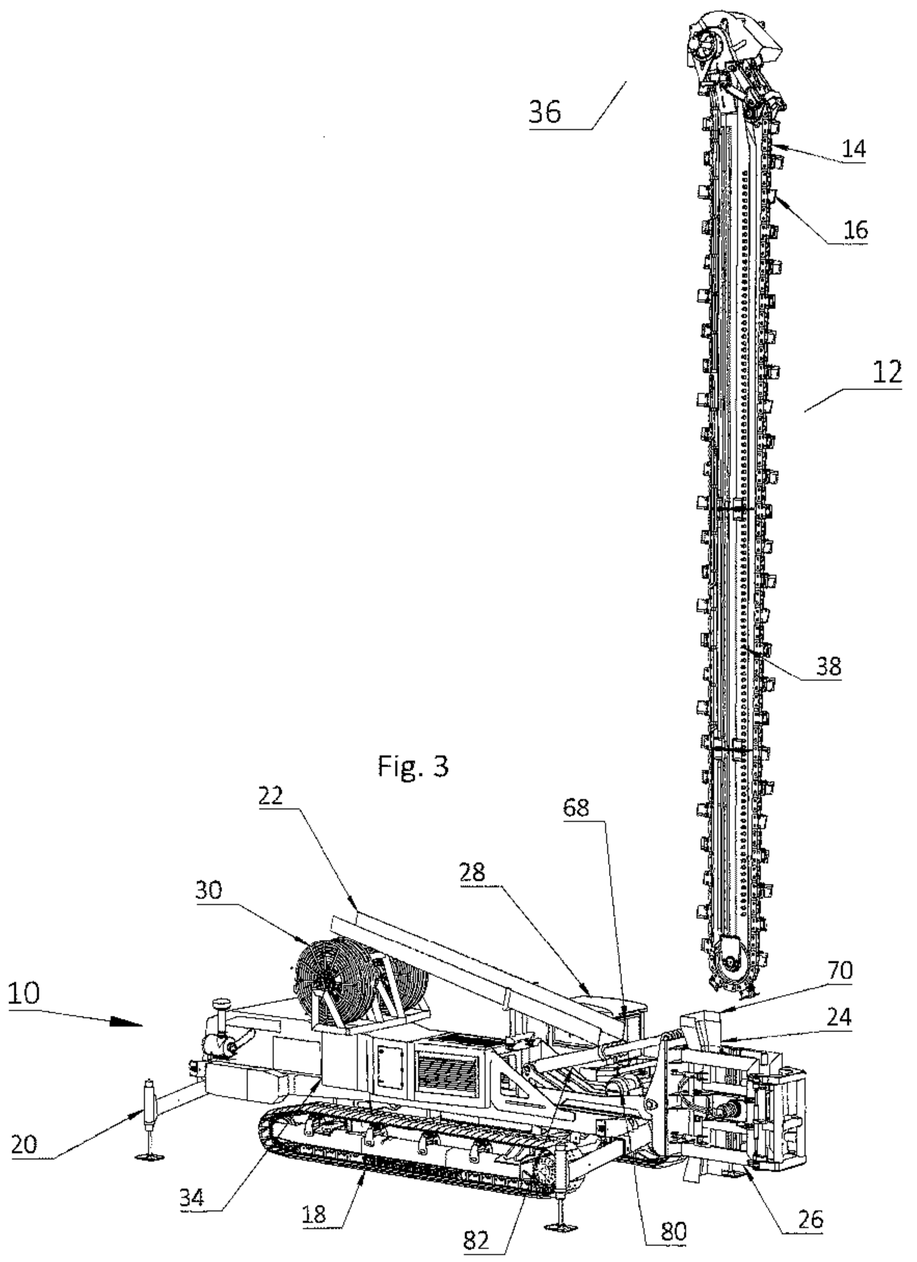

Fig. 3

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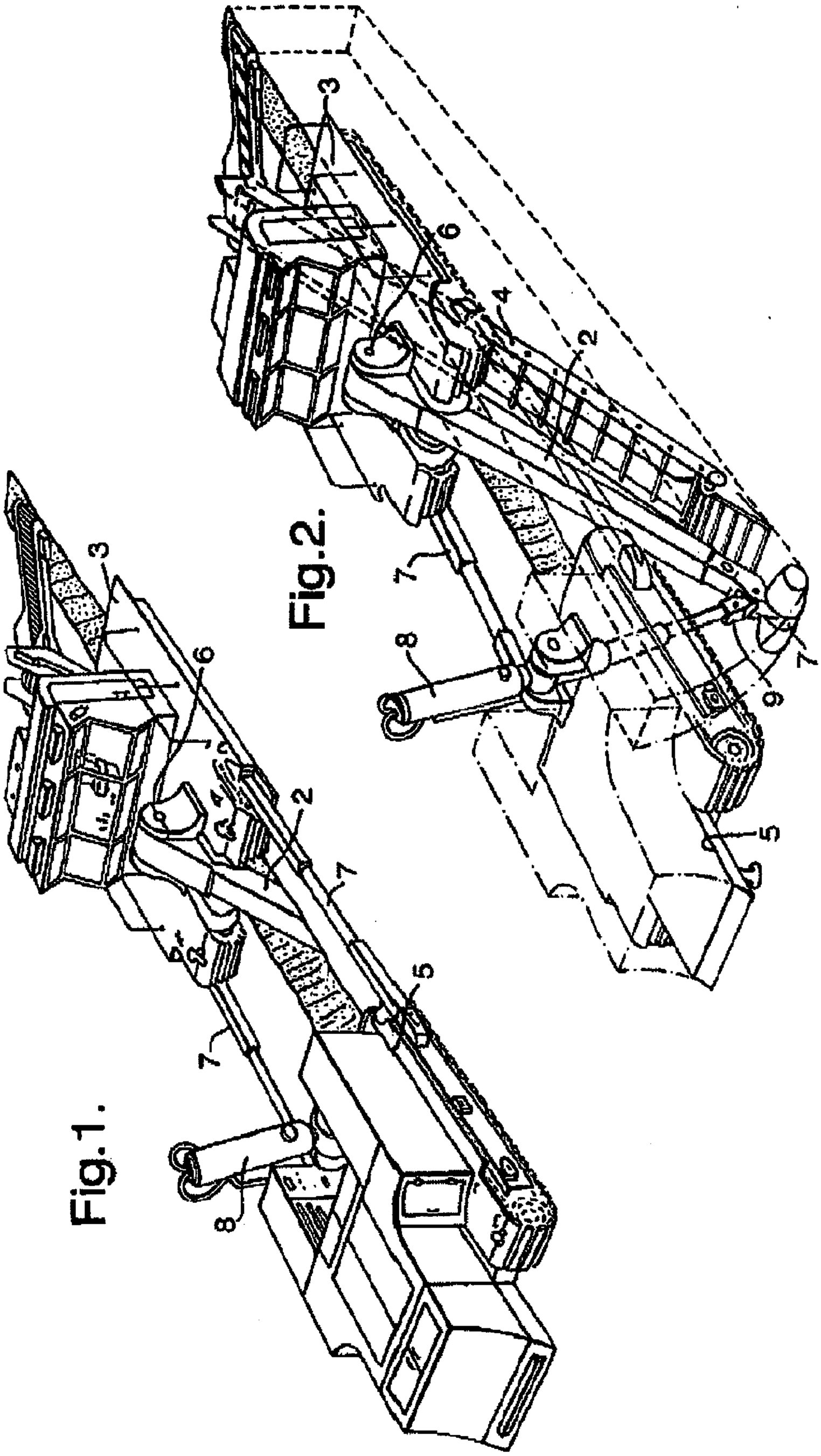

Fig.2.

Fig.1.

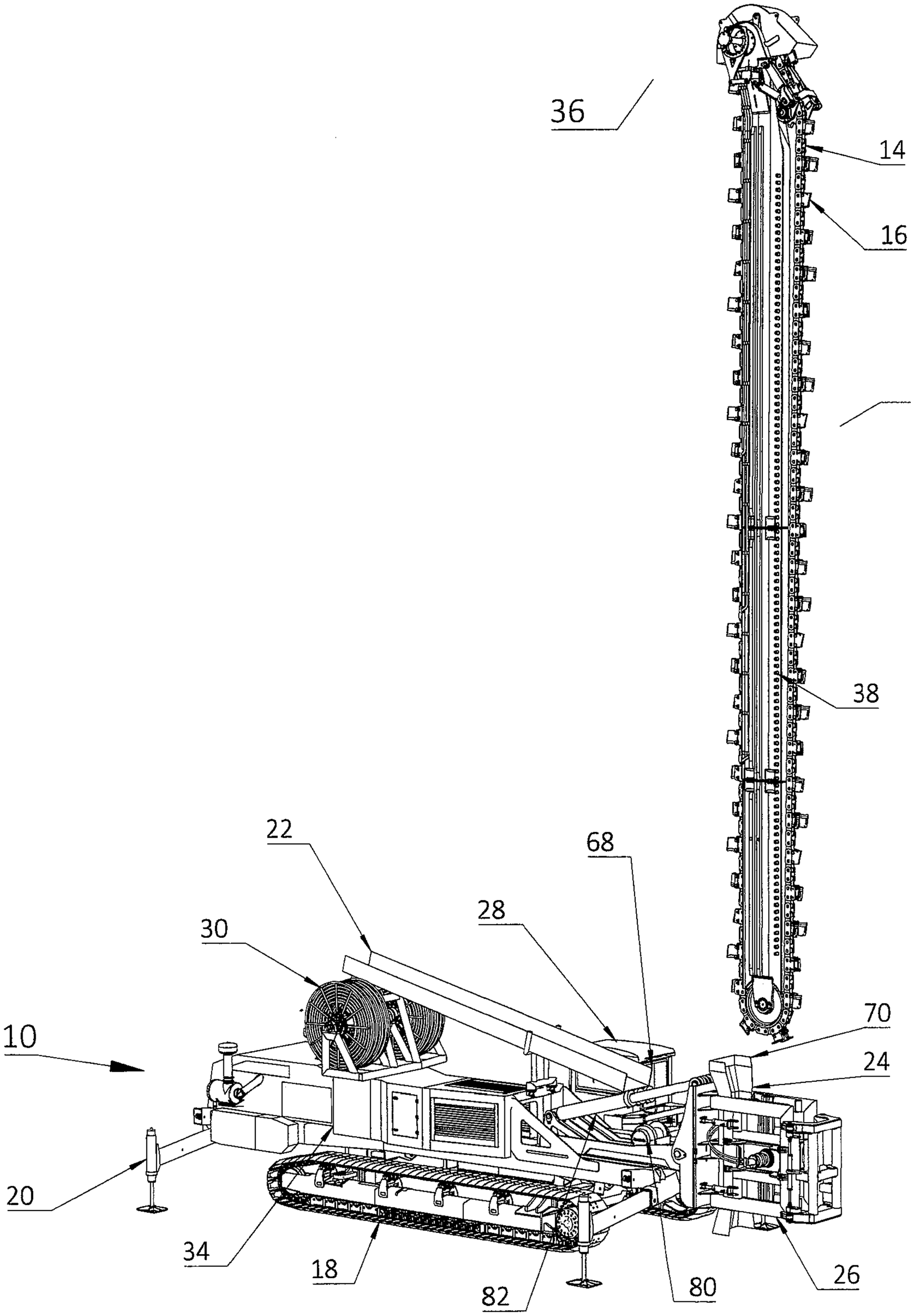

Fig. 3

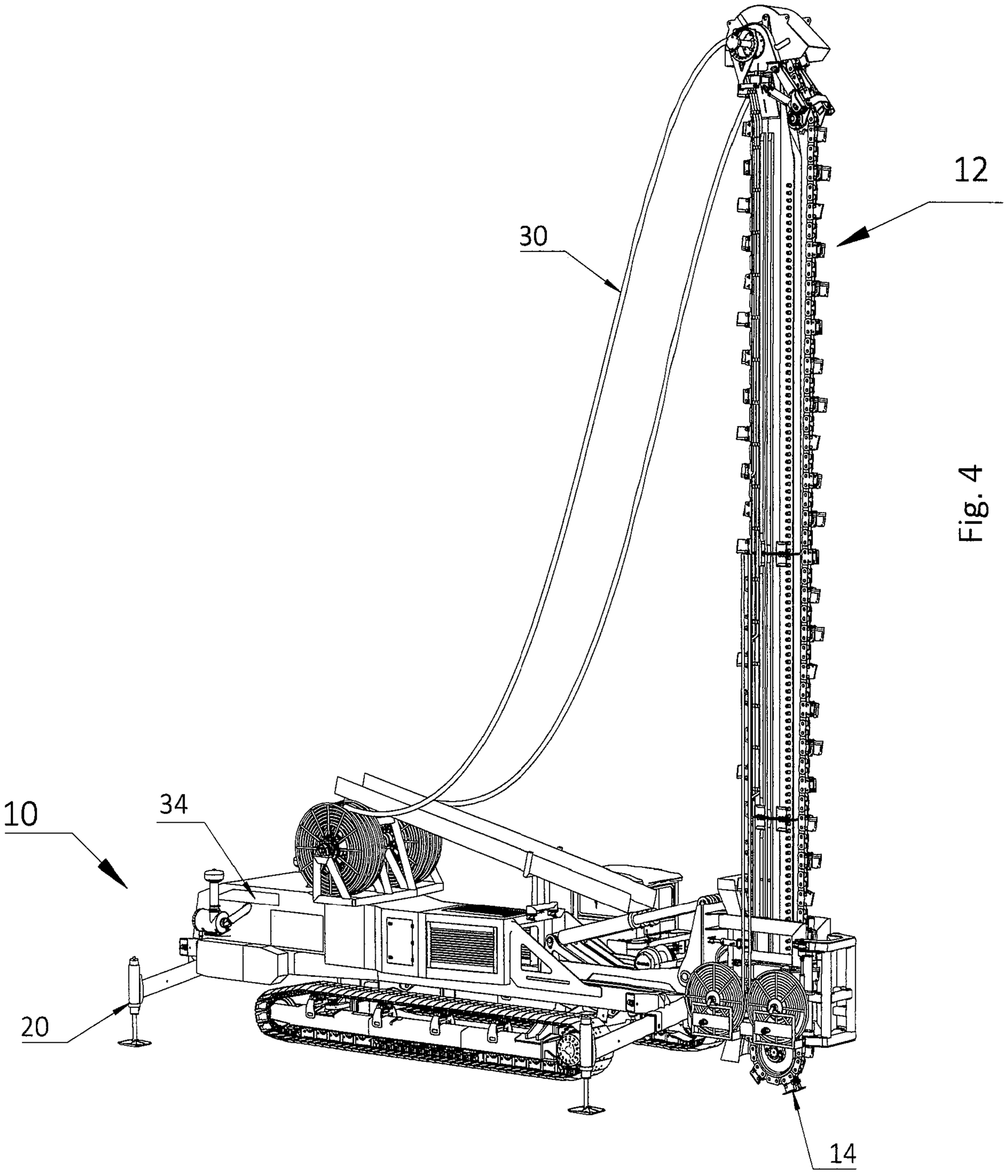

Fig. 4

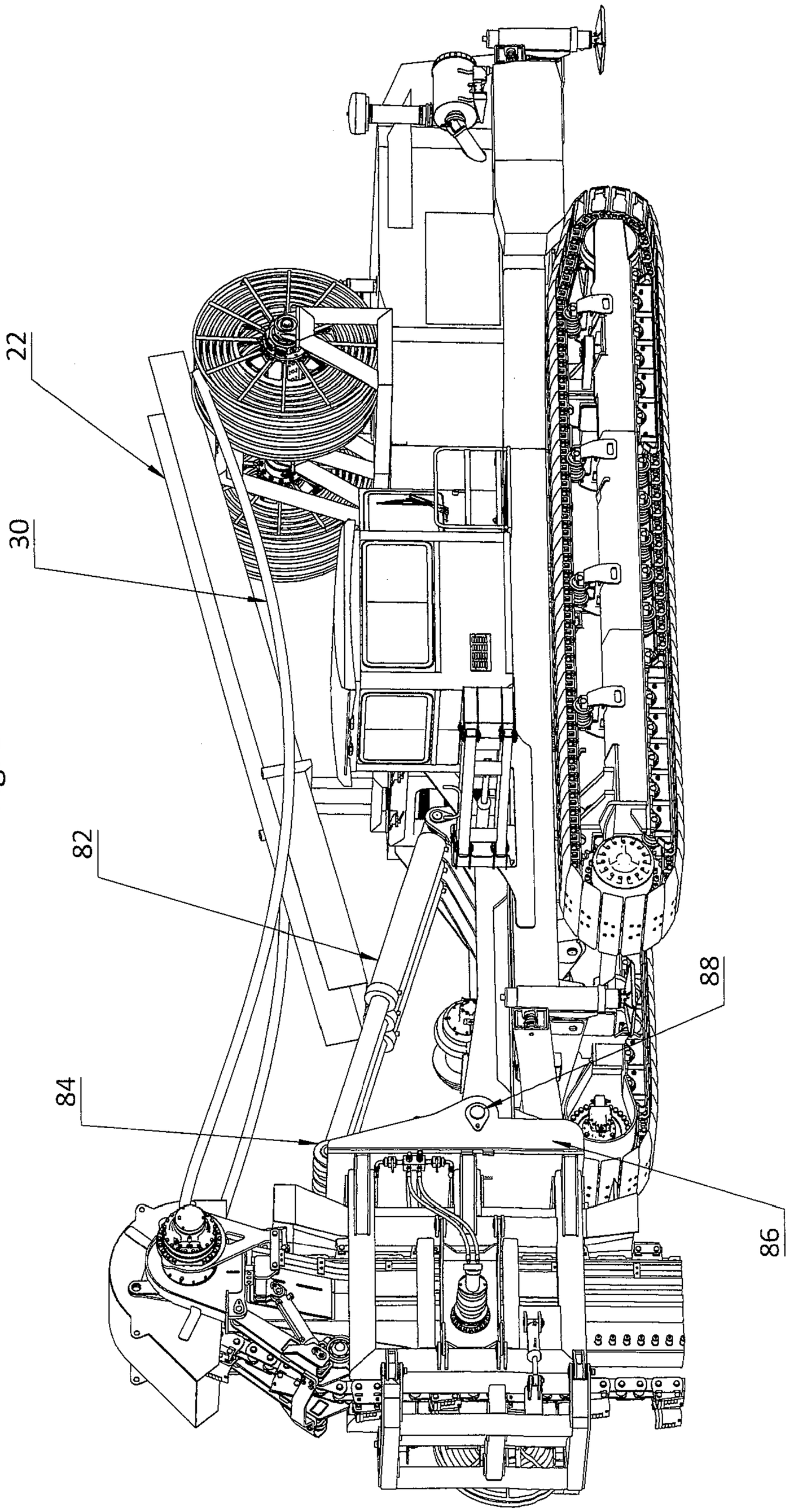

Fig. 5

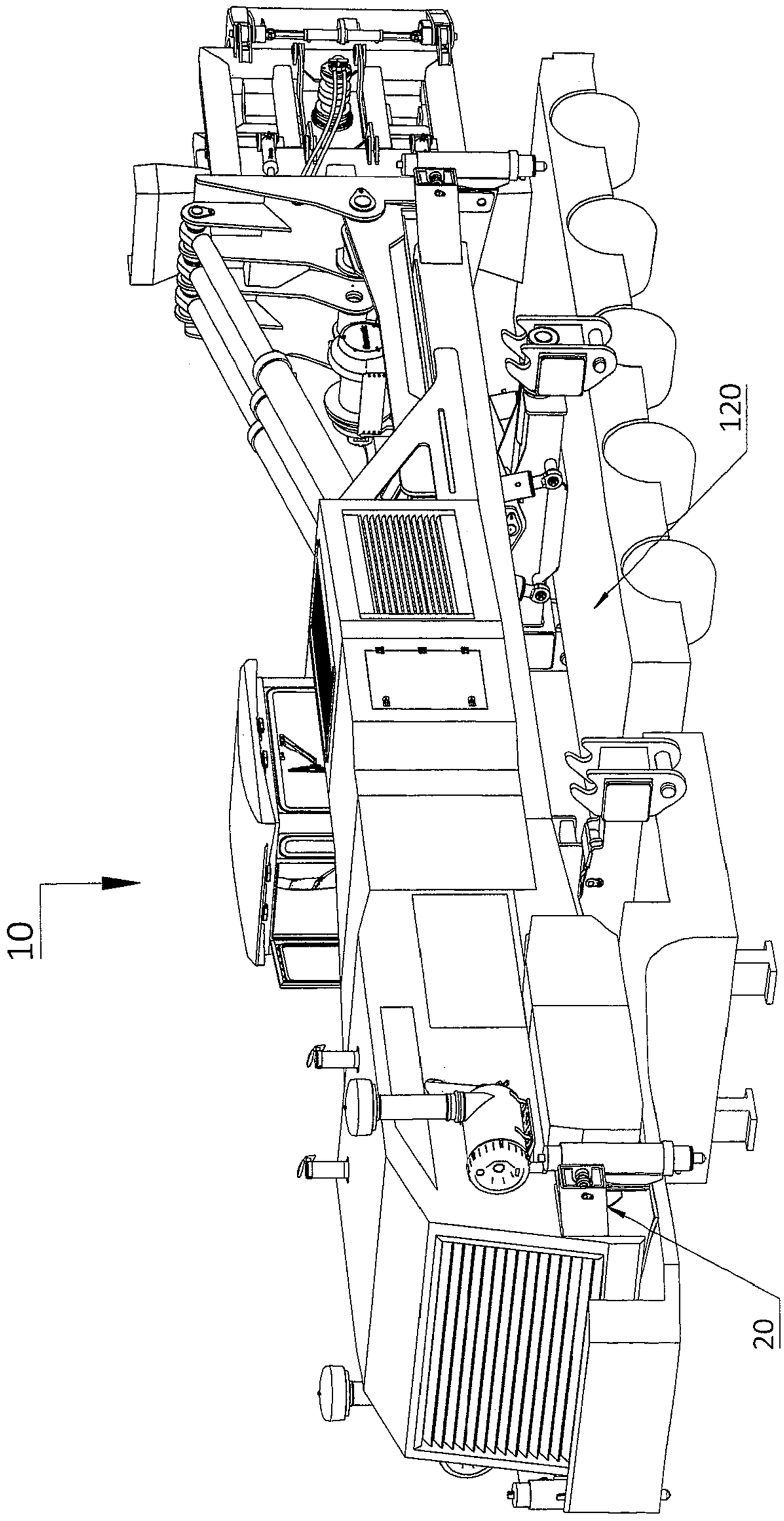

Fig. 6

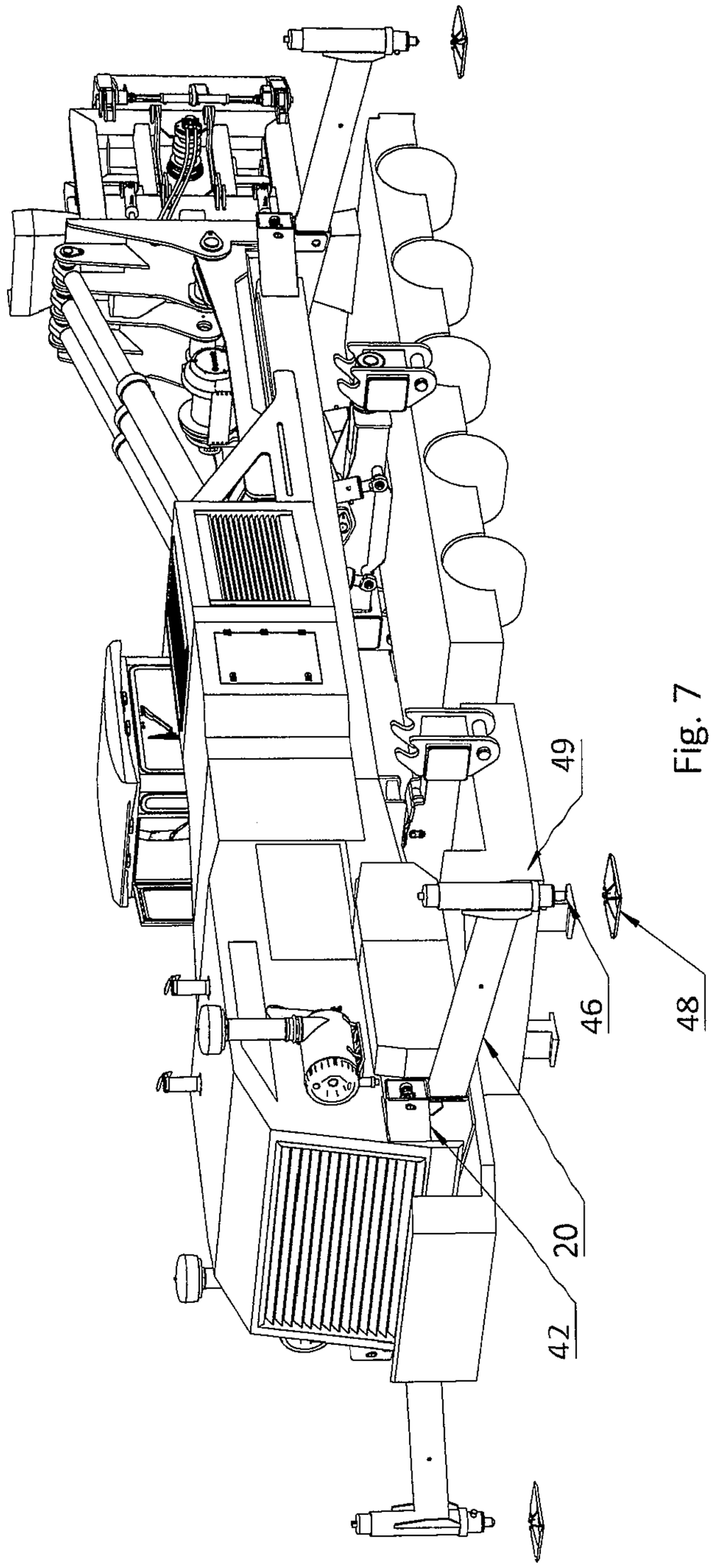

Fig. 7

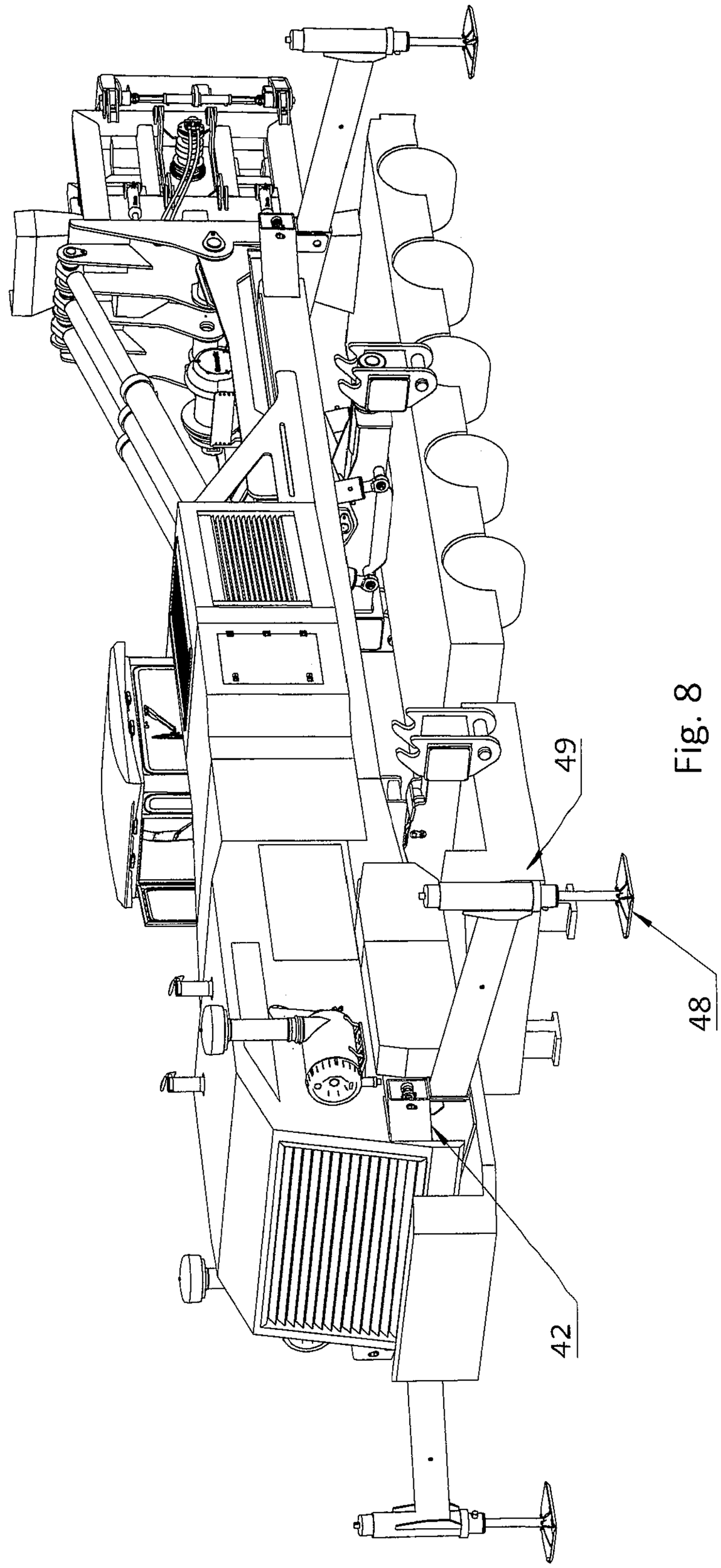

Fig. 8

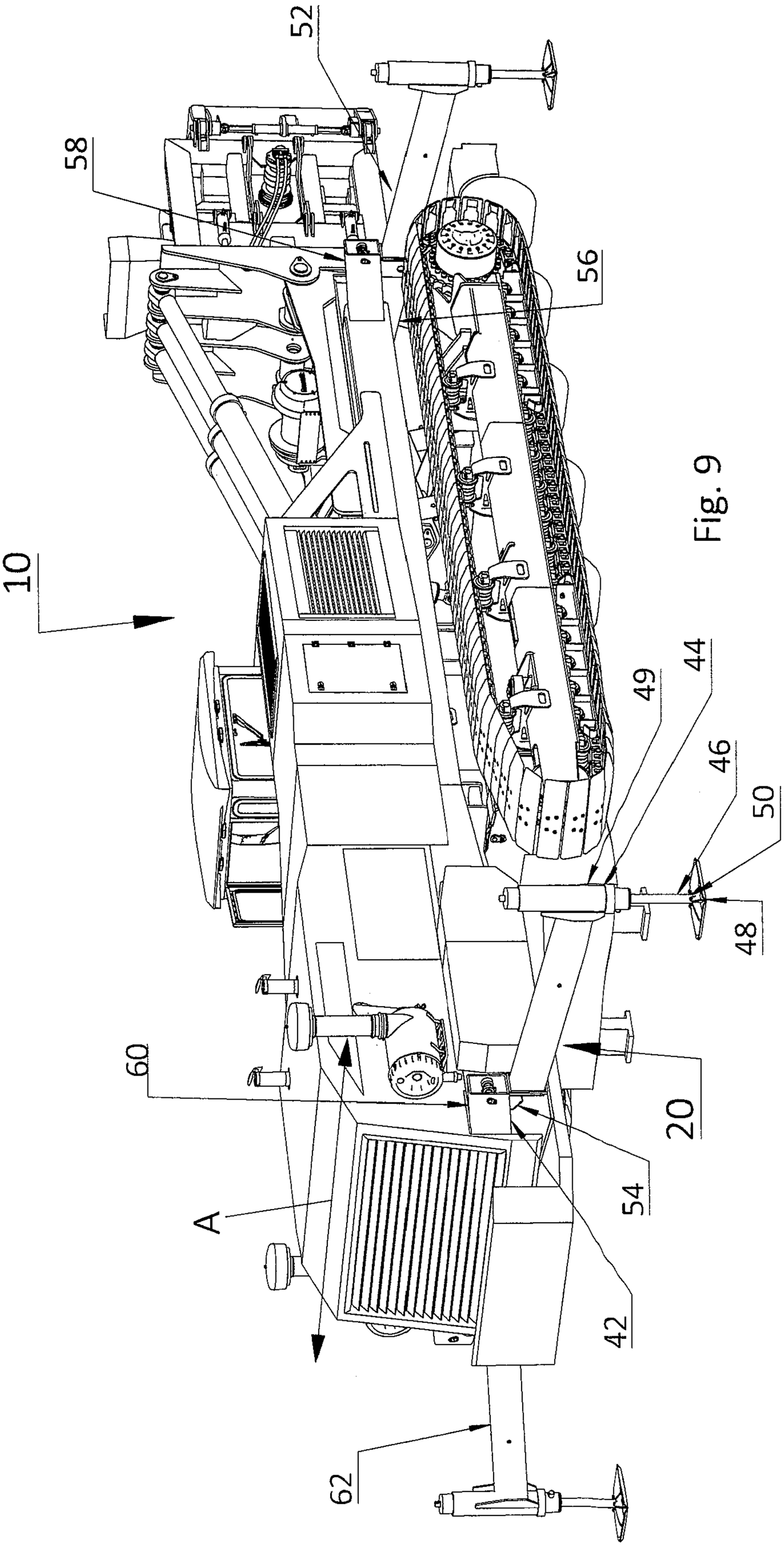

Fig. 9

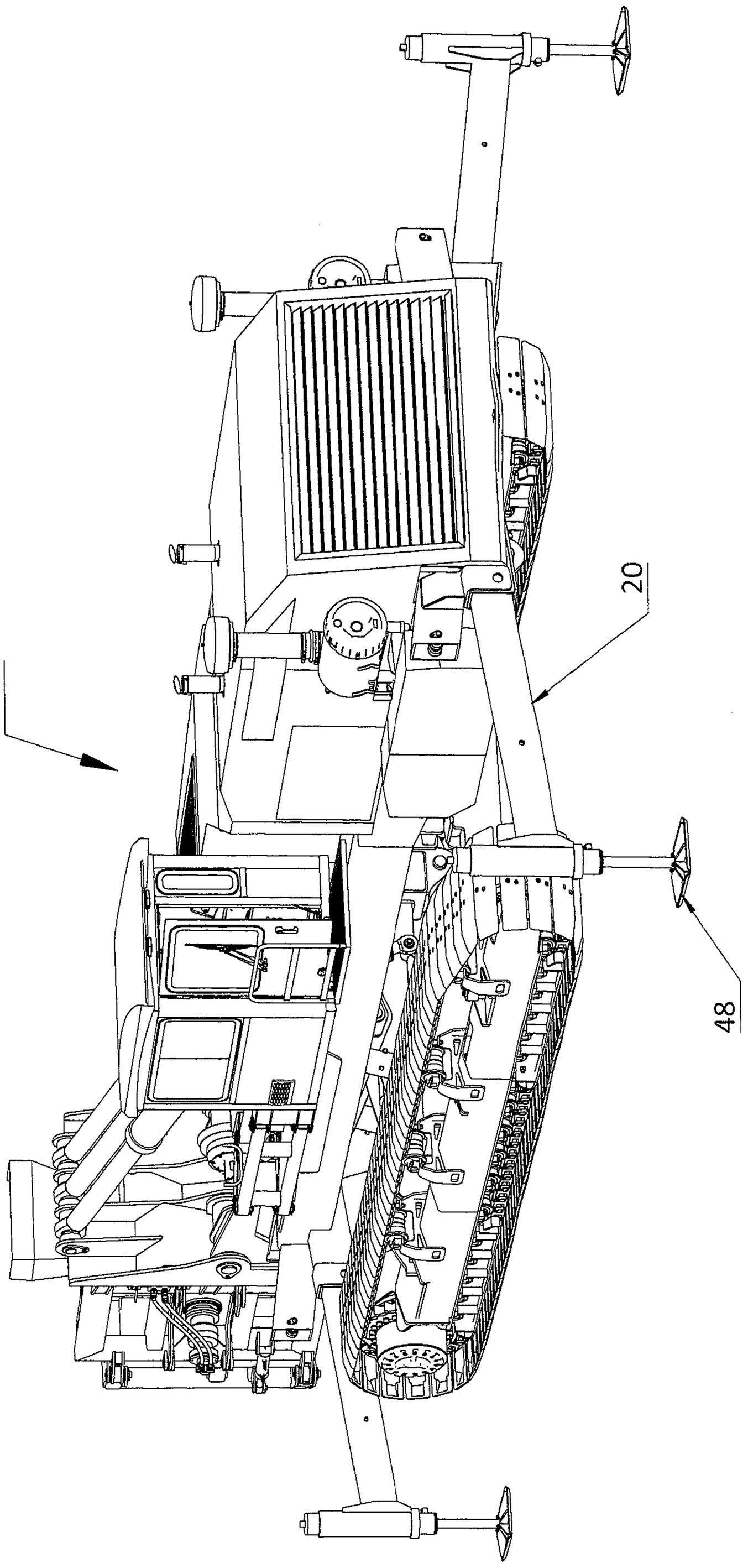

Fig. 9A

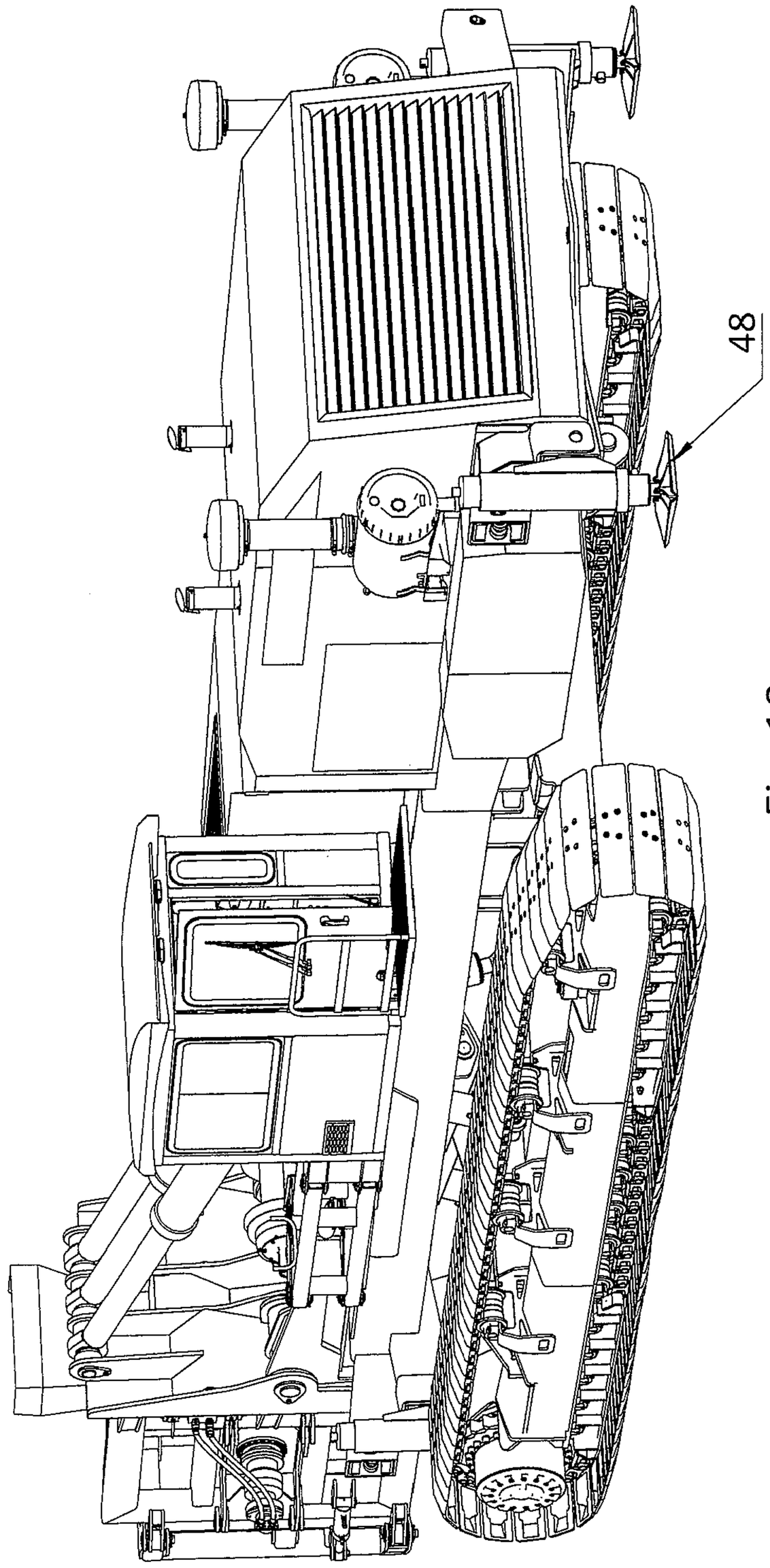

Fig. 10

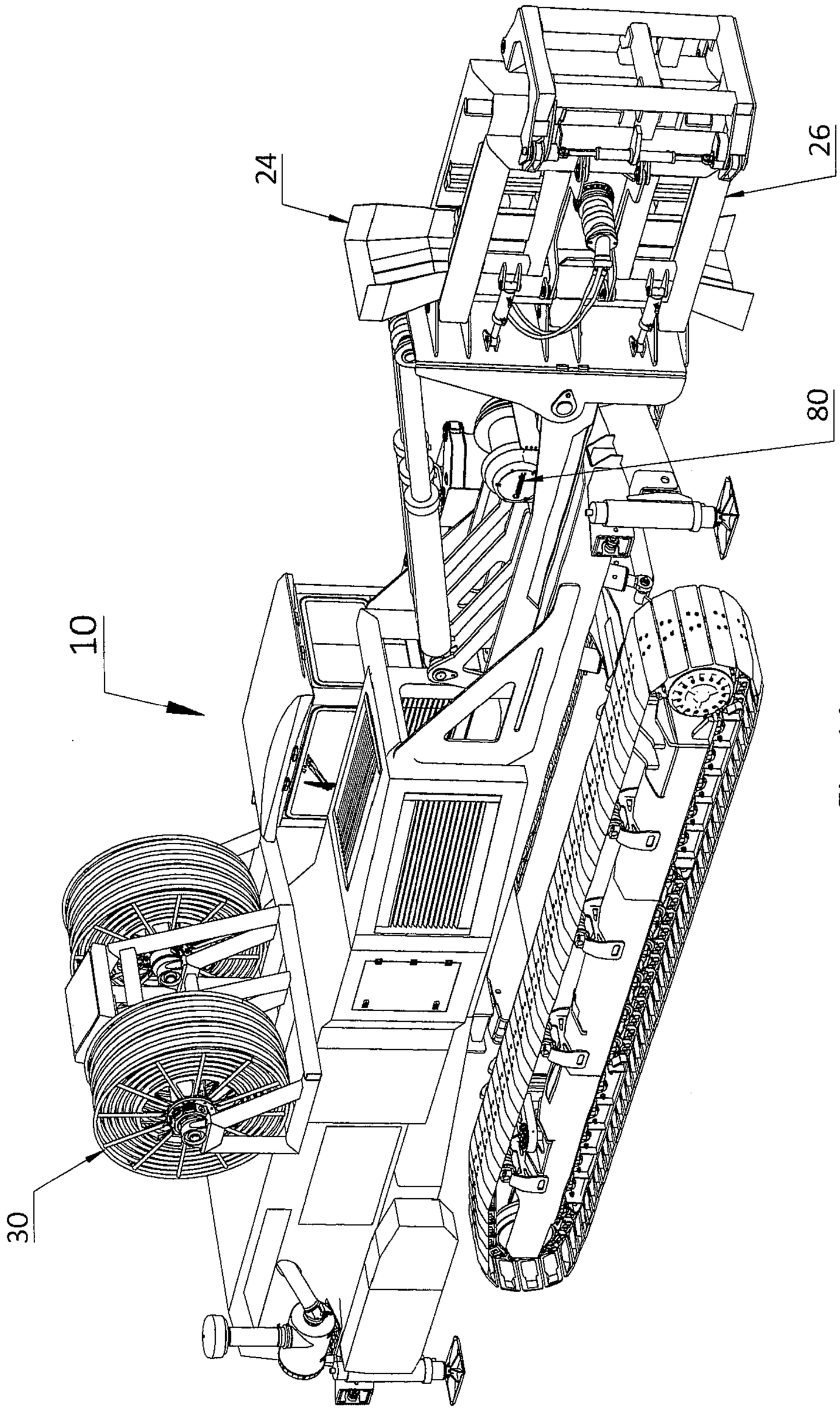

Fig. 11

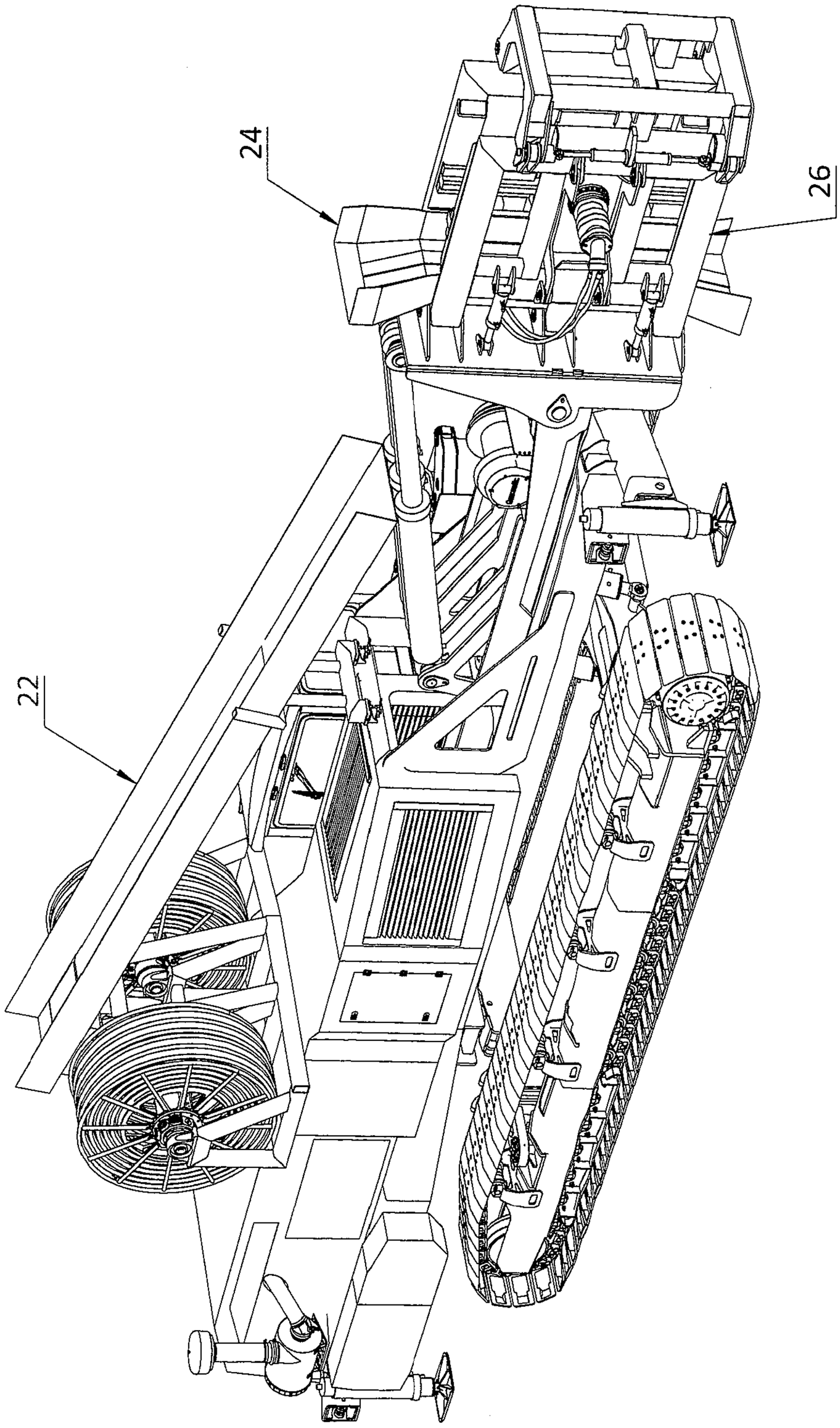

Fig. 12

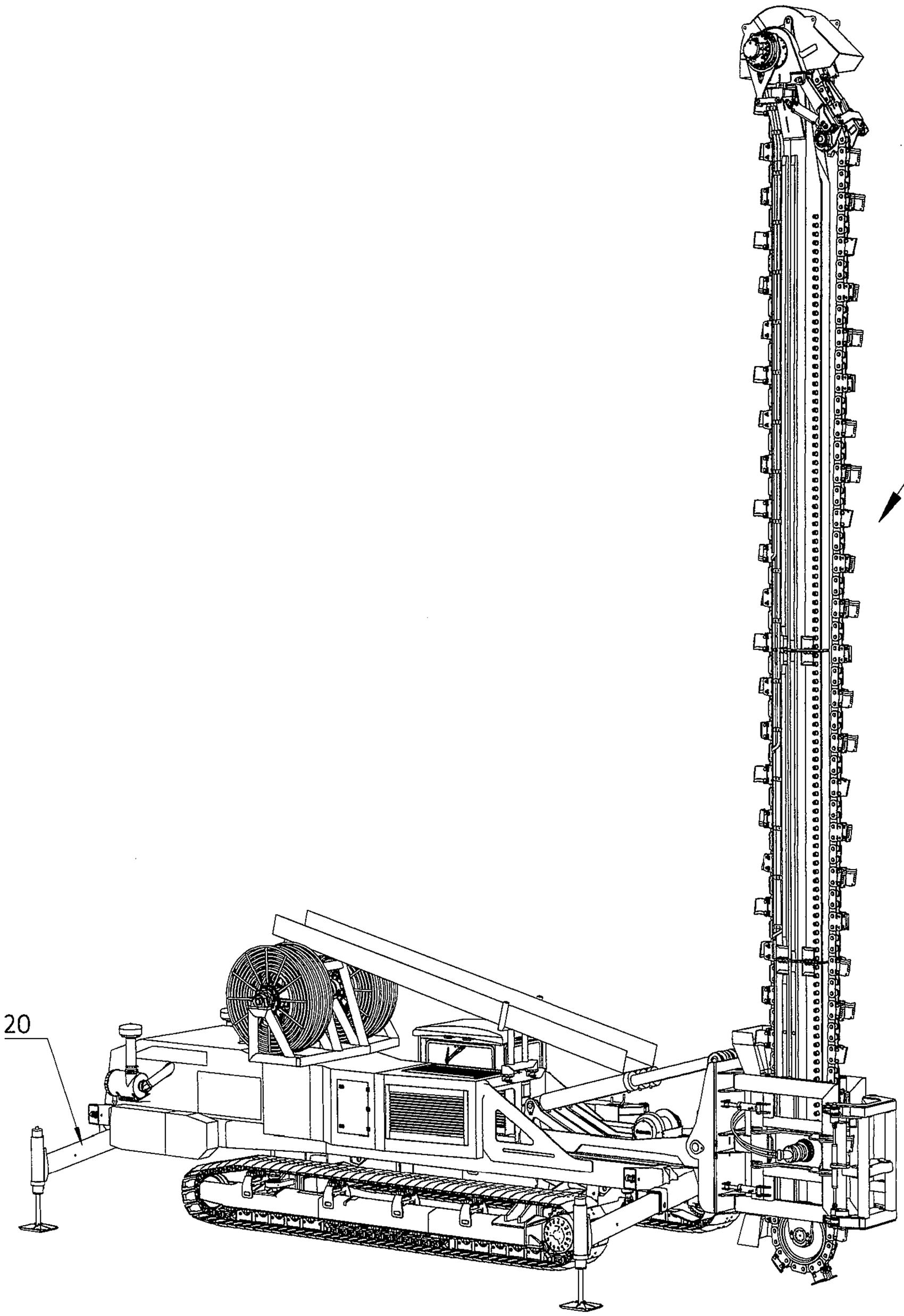

Fig. 13

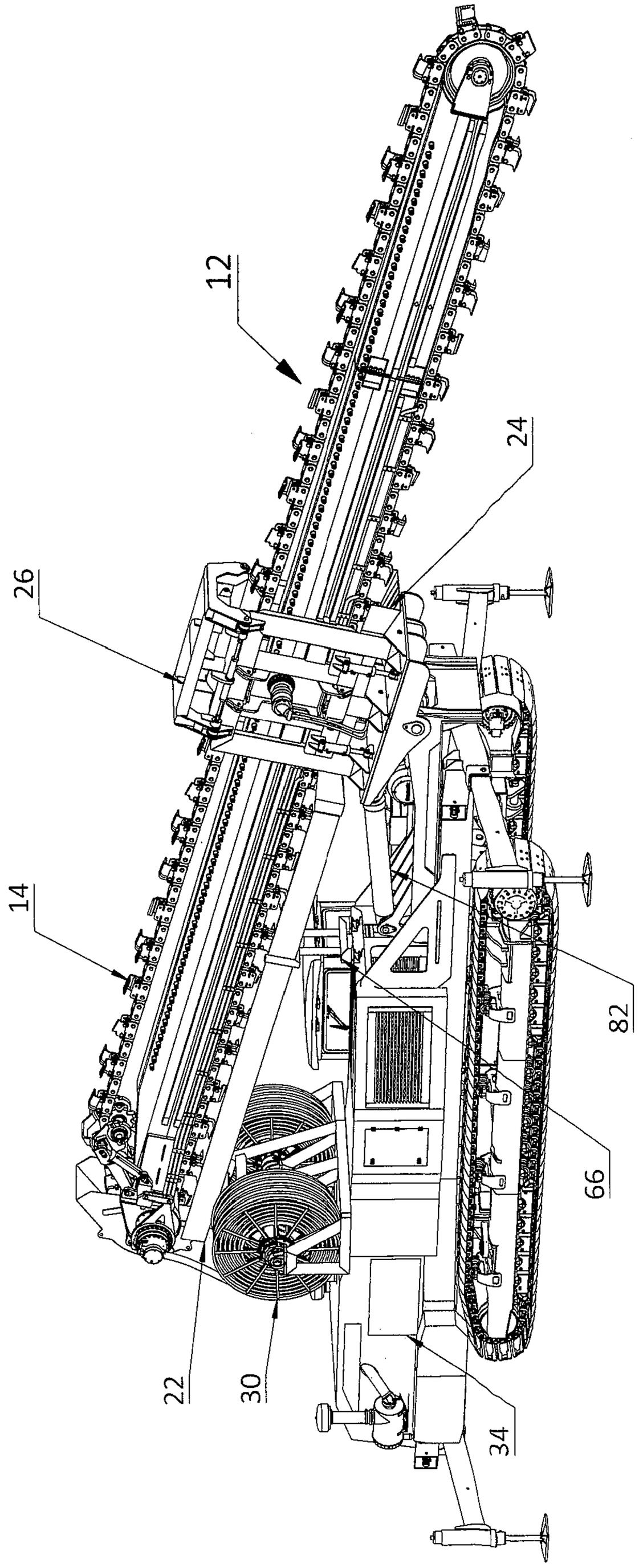

Fig. 14

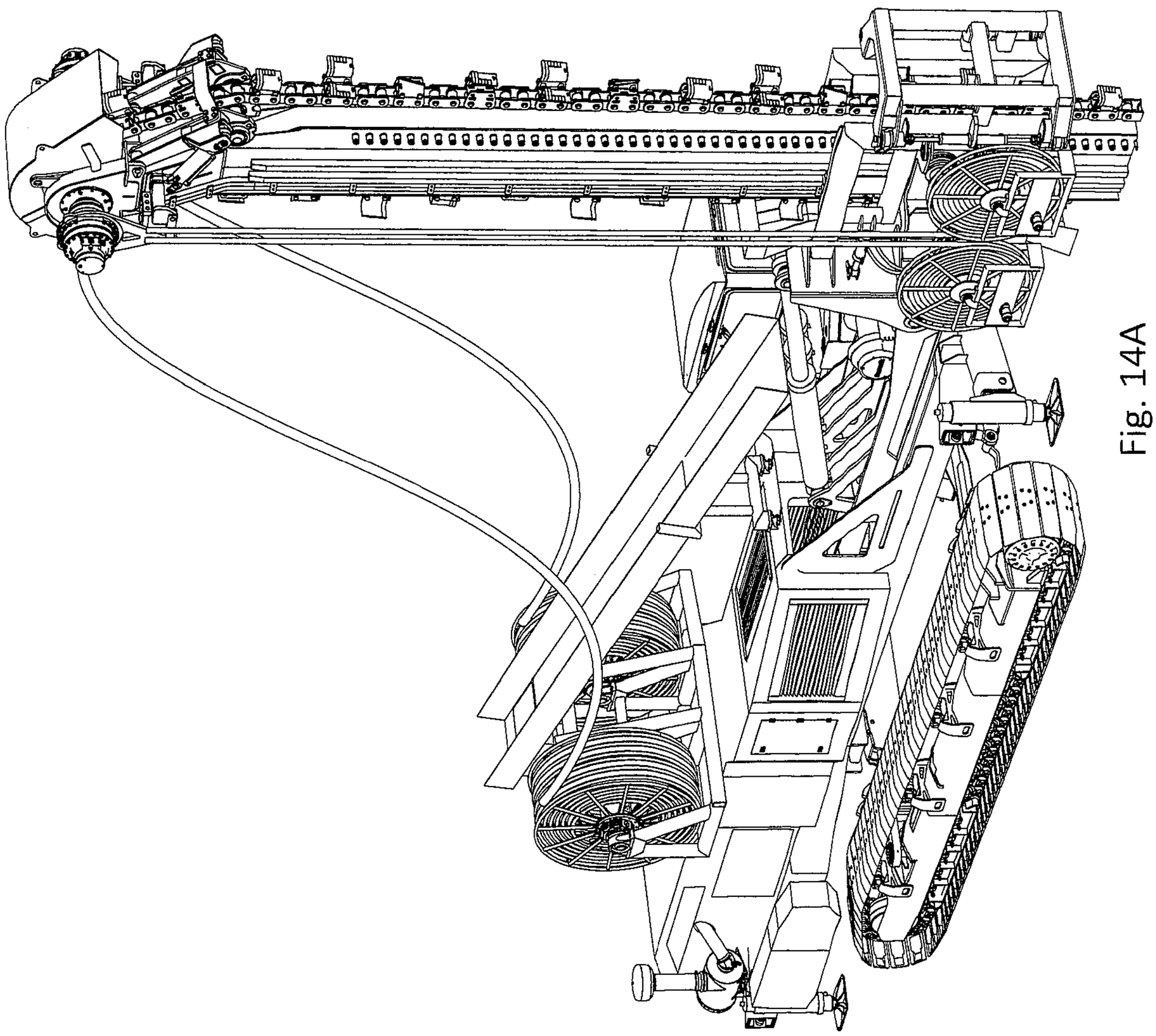

Fig. 14A

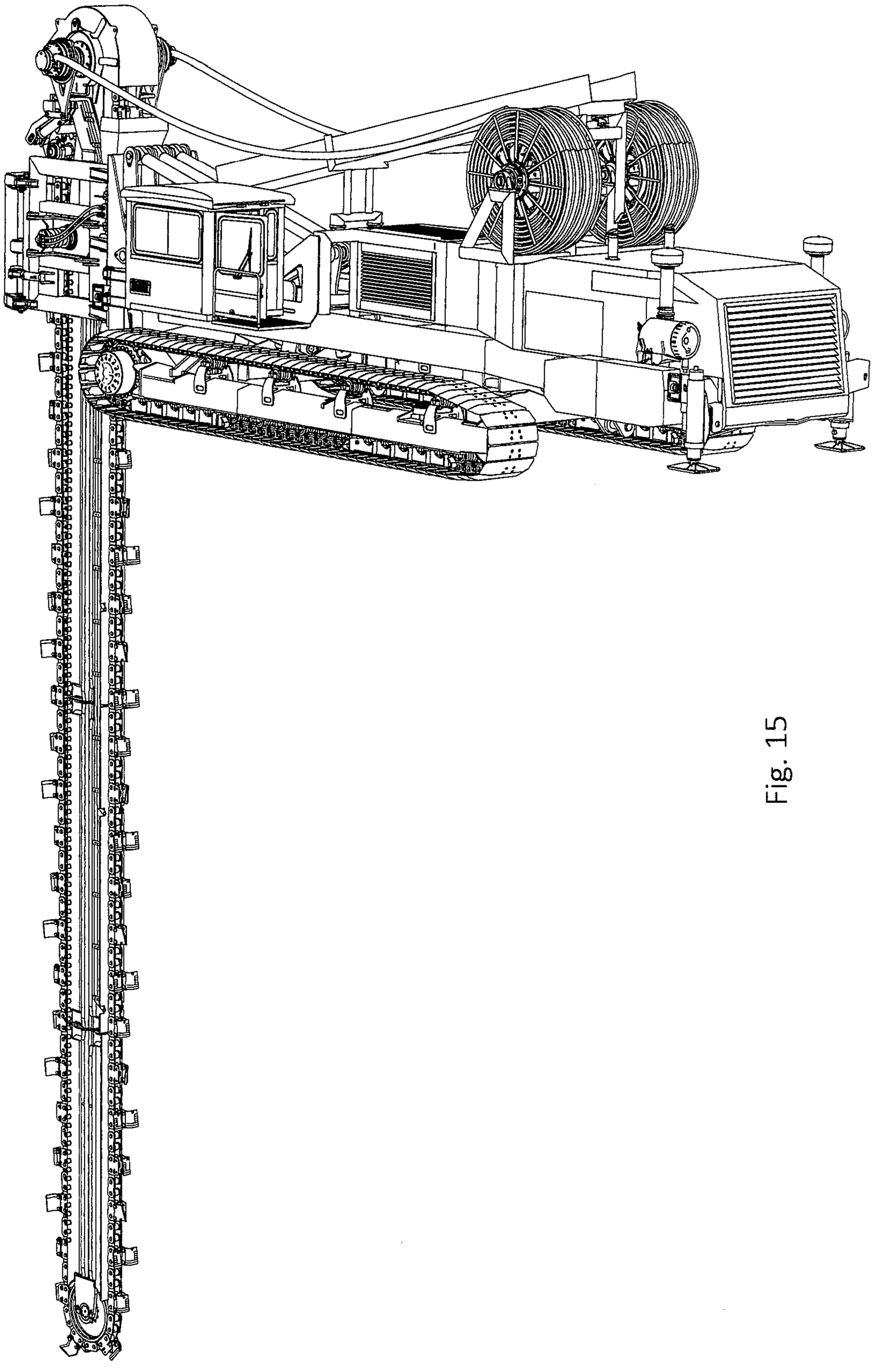

Fig. 15

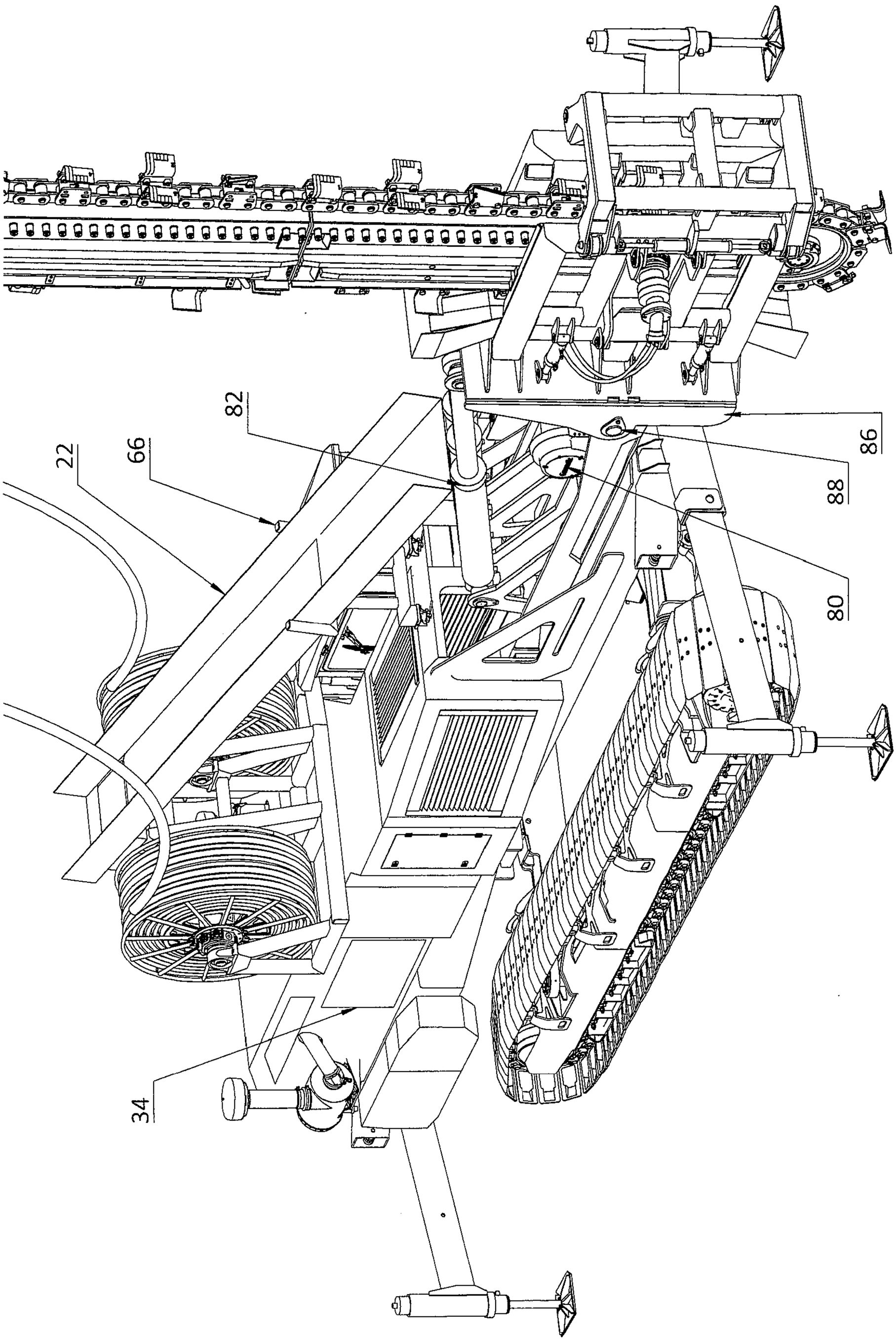

Fig. 16

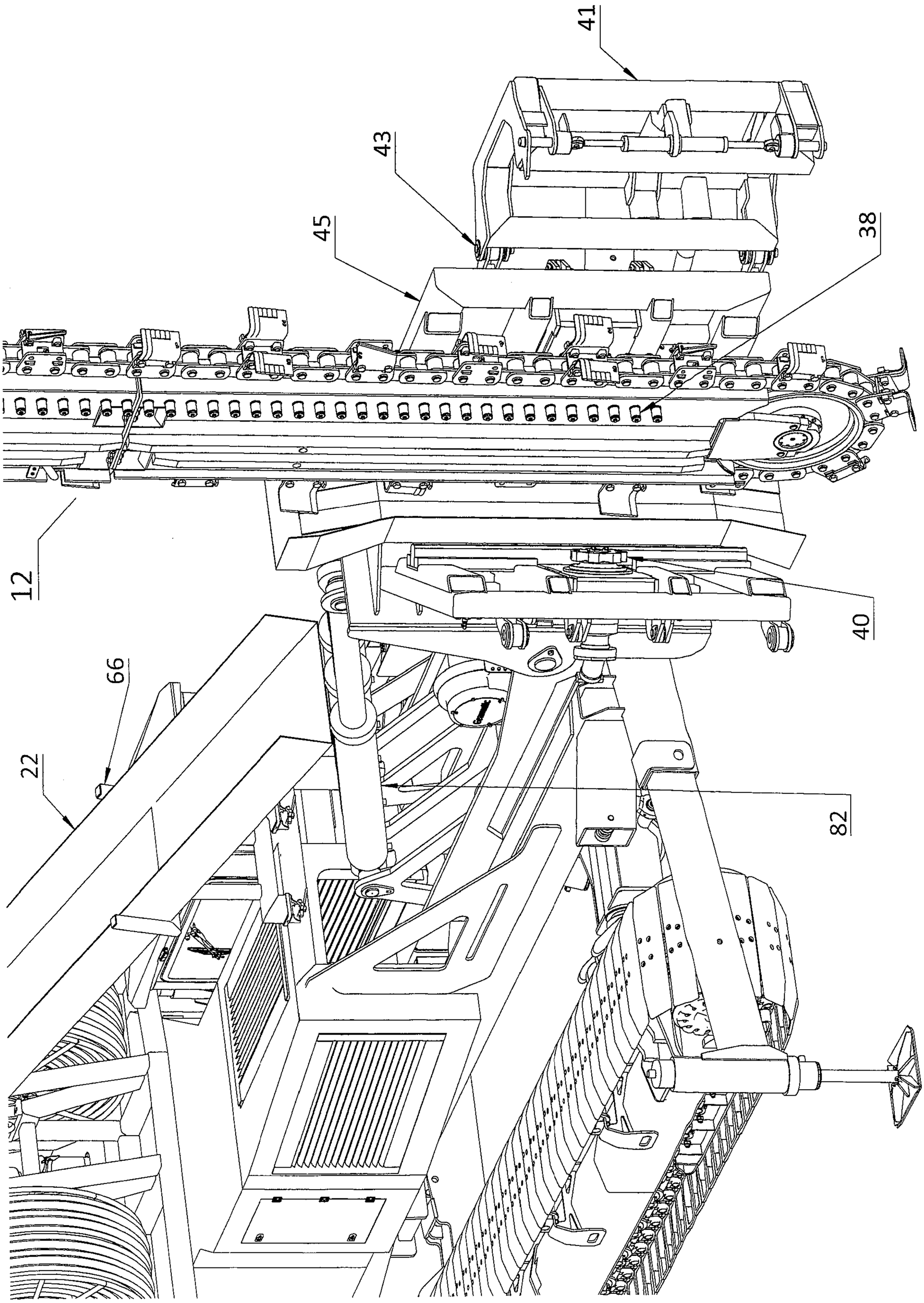

Fig. 17

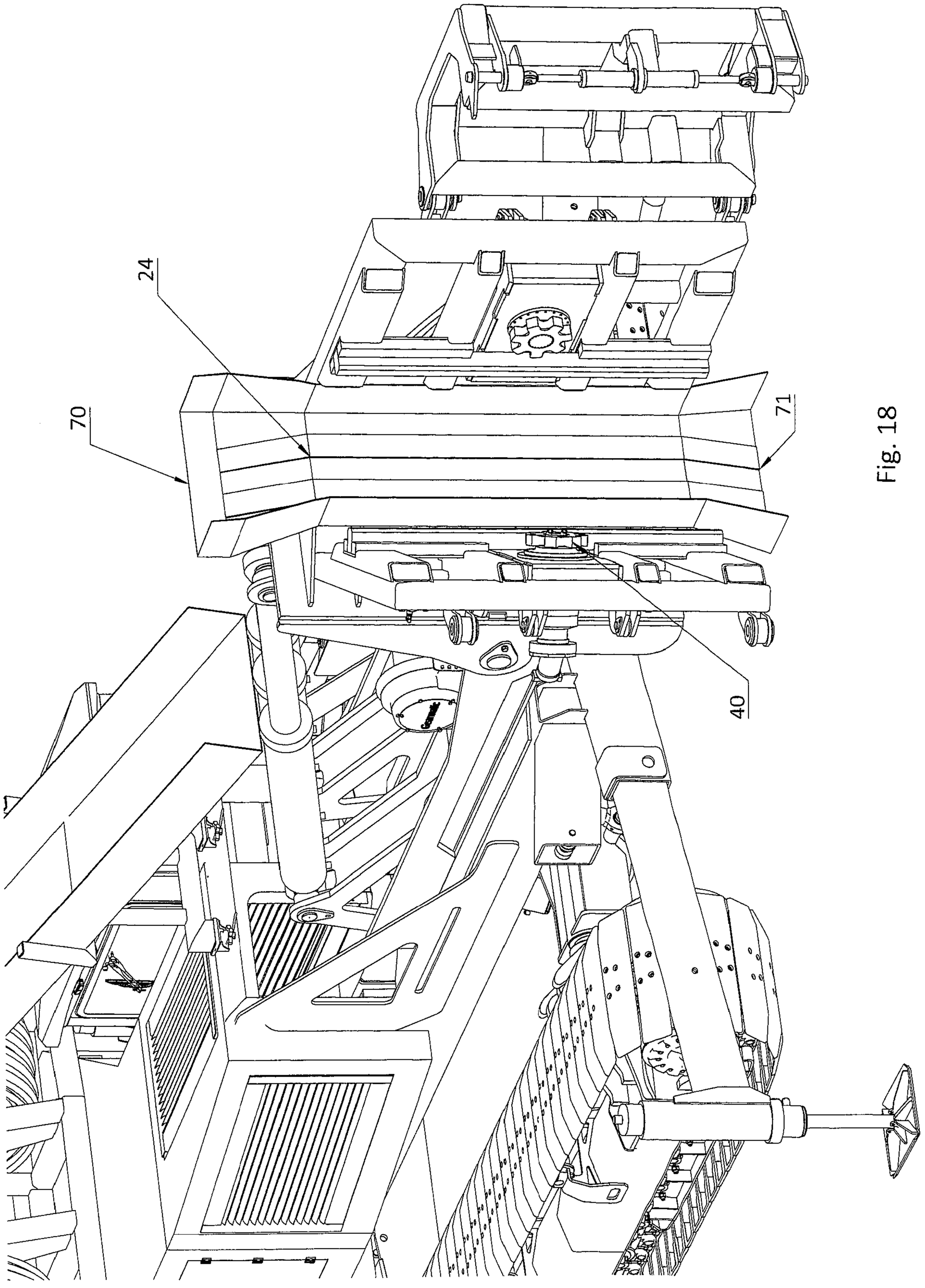

Fig. 18

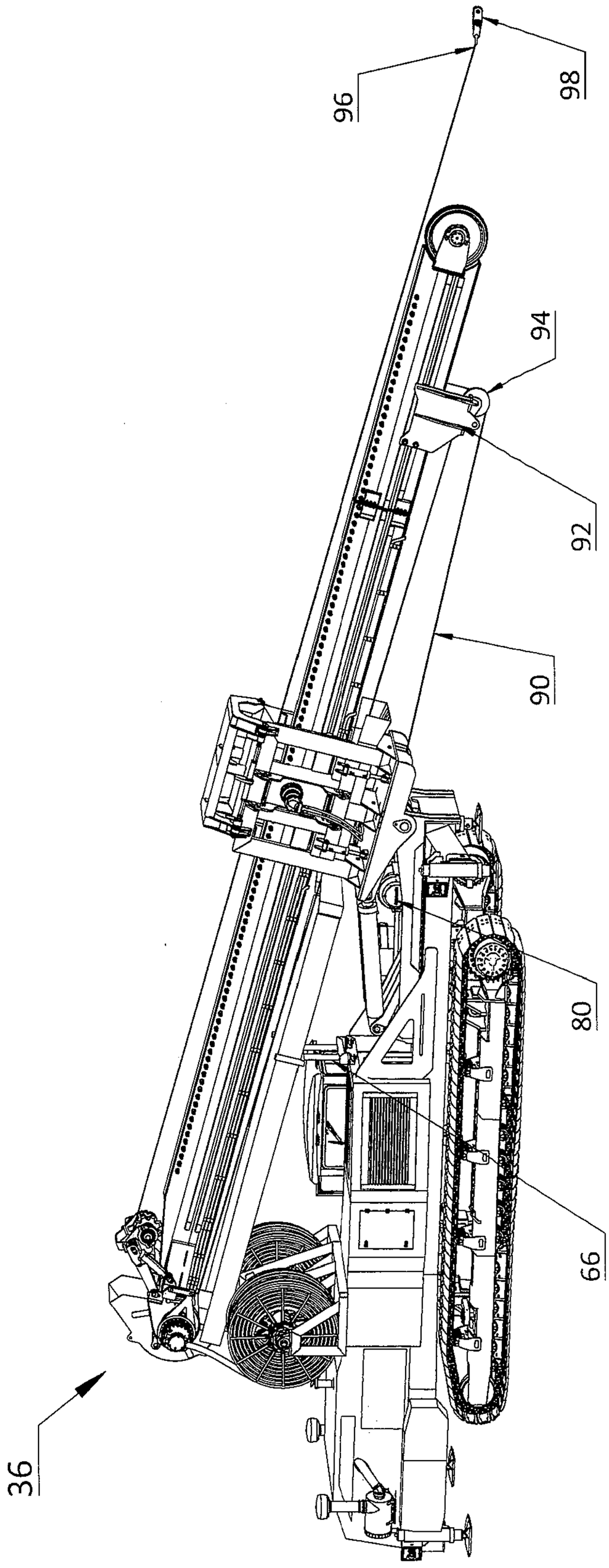

Fig. 19

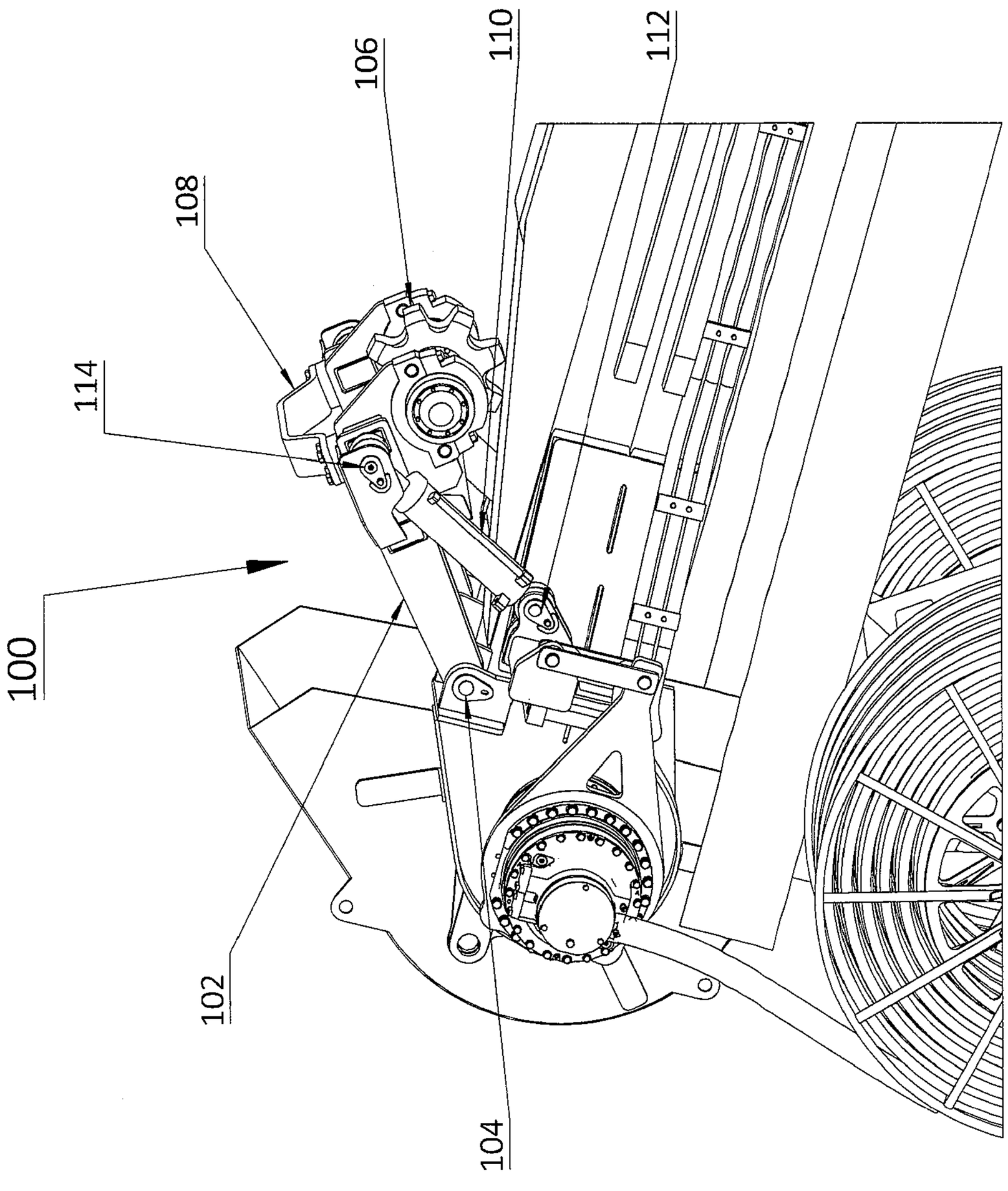

Fig. 20

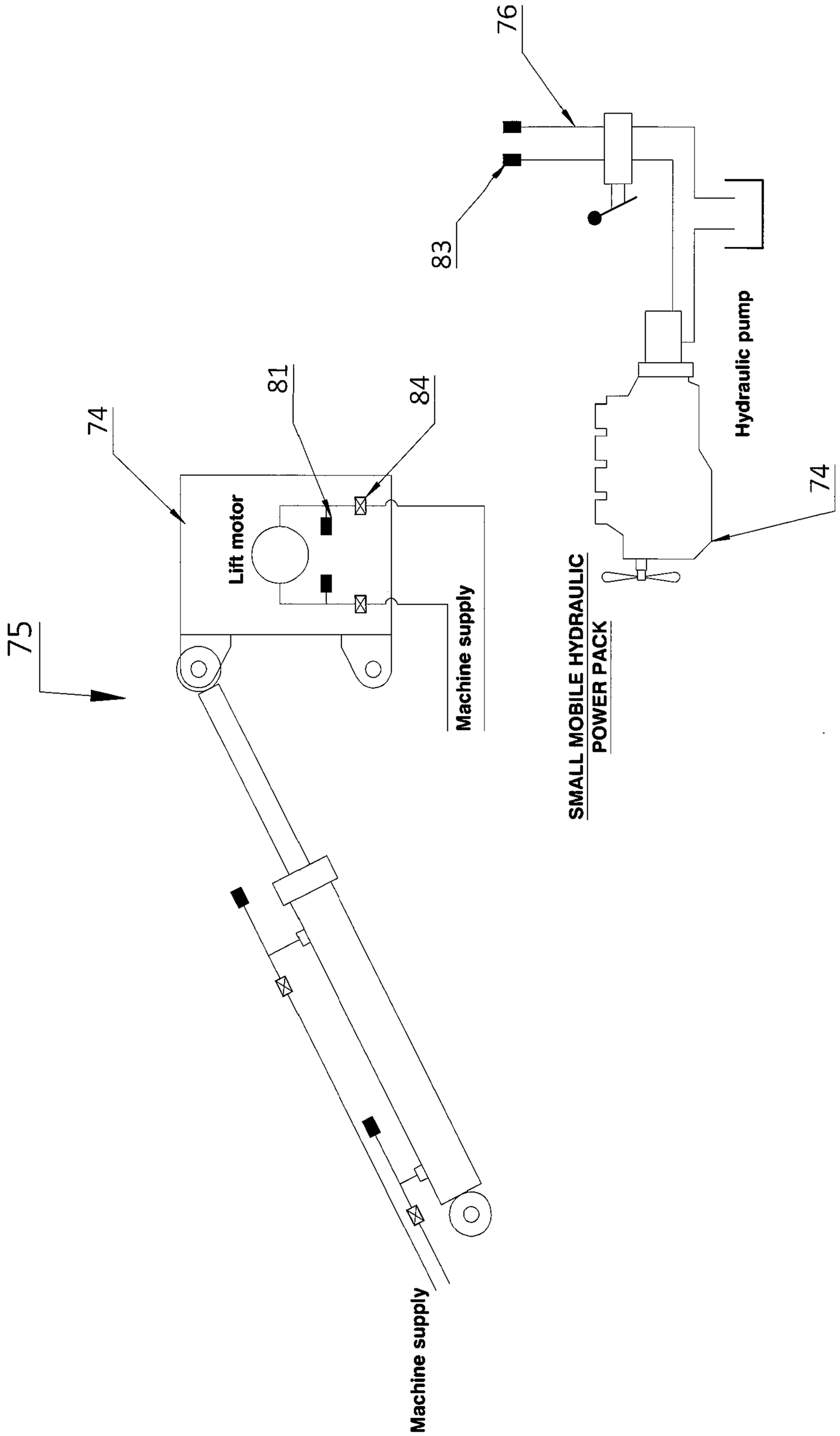
76
83
SMALL MOBILE HYDRAULIC
POWER PACK
Hydraulic pump
74
75
74
81
84
Lift motor
Machine supply

Fig. 21

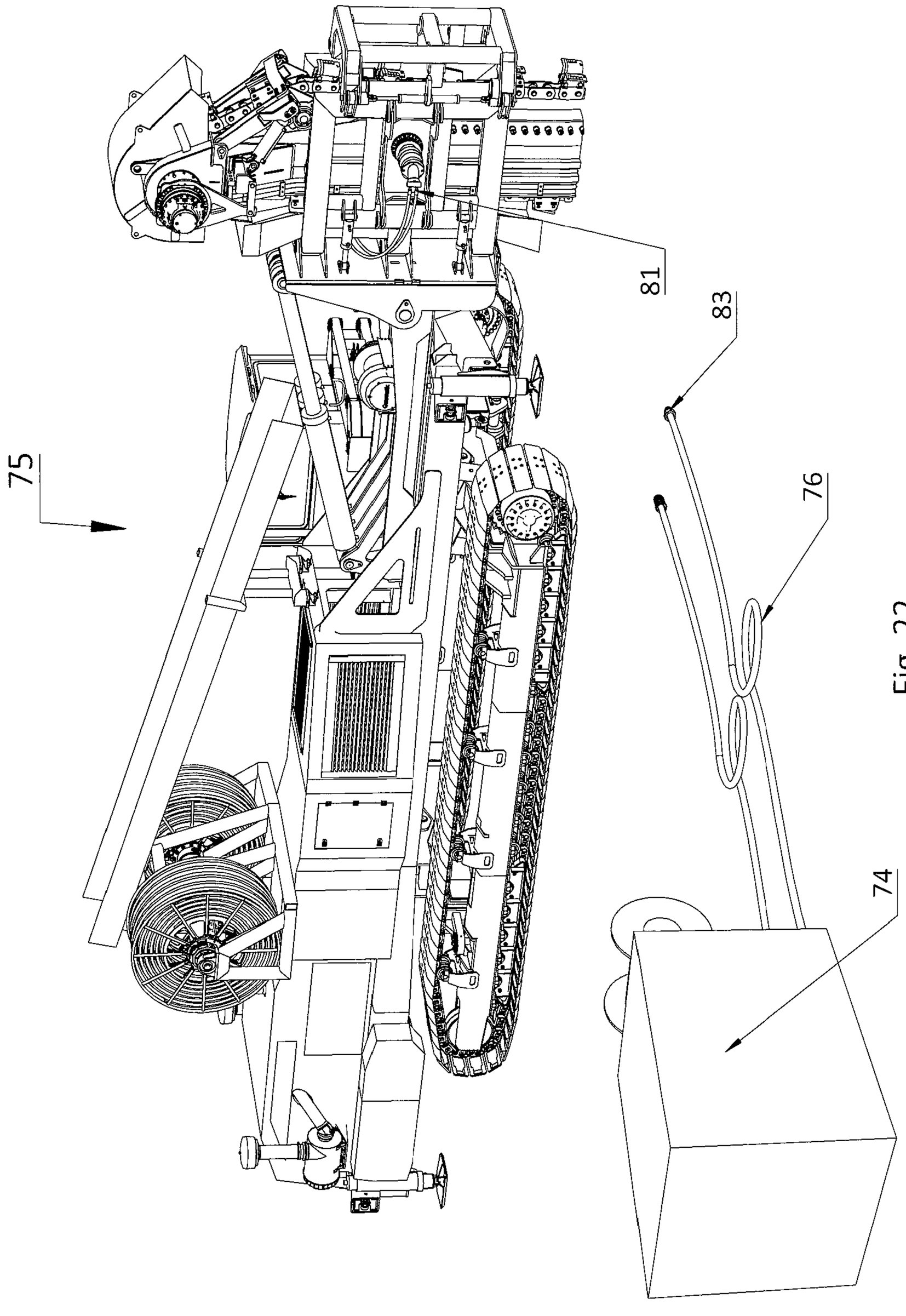

Fig. 22

Trenching Apparatus and a Method of Trenching

The present invention relates to trenching apparatus and a method of trenching.

There are many known trenching machines for digging trenches in soil by use of a prime mover such as a crawler tractor, or a conventional tractor pulling a trailer, in which a cutting device is positioned in the trench on a boom. The main examples are a cutting rotor rotating about an axis transverse to the trench, known as a ripper cutter, or one or more cutting rotors rotating about an axis aligned along the length of the boom, generally known as a milling cutter, or a cutting device having an elongate endless support means carrying a plurality of cutting elements and trained along upper and lower runs on the boom, known as a chain cutter. Where a cutting rotor is used this is mounted on the distal end of a boom projecting forwardly and downwardly from the prime mover, relative to the direction of digging of the trench. Where a chain cutter is used, this is normally mounted on a boom extending downwardly and rearwardly from the prime mover relative to the direction of cutting of the trench.

Examples of such trenching machines are found in, for example, CH-A-239498, WO-A-95/13433, WO-A-03/044286, US-A-6,467,201, EP-A-080,802, CN-A-2010 50077, CN-A-2517789, GB-A-786,829, WO-A-2007/035,400, JP-H04169696, US-A-5,540,006, GB-A-972,208, GB-A-848,277, GB-A-735,116, US-A-6,470,607, GB-A-1,118,907, GB-A-2,088,930, GB-A-155,766, GB-A-2,551,419 and WO-A-2012/123,622.

There are also known types of trenchers that are arranged to utilize a vertical cutting boom. Examples include trenchers provided by Soletanche Bachy. In particular, one example of equipment provided by Soletanche Bachy suitable for deep trenching is known as the TM-80.

<u>One known system for trenching is provided by Hayward Baker Inc and is known as Trench cutting and Remixing Deep (TRD) Soil Mix Walls. The system is described at https://www.haywardbaker.com/uploads/solutions-techniques/trd-soil-mix-walls/Hayward-Baker-TRD-Brochure.pdf. As explained in this reference, the system utilizes a sectional vertical cutter made of cutter post sections that are assembled *in situ.*</u>

According to a first aspect of the present invention there is provided a trenching apparatus, comprising: a body moveable on the ground surface, a ground engagement boom associated with the body, wherein the ground engagement boom comprises a chain for

interacting with earth in use; lifting means arranged to control and configure the ground engagement boom so as to enter the ground and to configure the boom to an inclined orientation in which the boom extends at least partially over the body; a winch provided on the body to engage with the chain of the ground engagement boom when in the inclined orientation.

In an embodiment, the ground engagement boom is movable in a substantially vertical plane.

There is provided a trenching apparatus in which a winch for changing the chain on a chain cutting or mixing boom is provided on the trenching apparatus (or body thereof) itself, and not on the boom itself. Positioning of the winch in the present system on the body of the machine or apparatus itself enables and ensures that a chain can easily be changed on the ground engaging boom irrespective of the size of the ground engaging boom and the associated size and weight of the cutting chain itself.

In an embodiment, the ground engagement boom is a cutting boom for cutting earthen material from the end surface of the trench.

In an embodiment, the ground engagement boom is a mixing boom for mixing an agent such as (but not limited to) cement with earth within the trench.

In an embodiment, the longitudinal length of the ground engagement boom is between 10 and 20 metres.

In an embodiment, the ground engagement boom weighs between 10 and 20 tonnes, and preferably weighs up to 15 tonnes.

In an embodiment, the apparatus comprises a protection chute provided on the body of the trencher to protect the body from material that falls from the boom and to support the boom in the inclined orientation.

In an embodiment, the apparatus comprises a spool with a cable having an end connector for engagement with the end of a replacement chain to be put on the ground engagement boom when in the inclined orientation.

In an embodiment, the cable is routed via a shoulder on the distal end of the ground engagement boom to enable substantially the entire length of the ground engagement boom to be surrounded by the replacement chain.

In an embodiment, the shoulder comprises a pulley.

In an embodiment, the shoulder is slidably mounted on the body of the boom so that it can be moved from the top end to the distal end at which end it can be used to change the chain on the boom.

A shoulder is provided slidably mounted on the boom for housing a pulley or routing point for directing the cable of the winch used when changing the chain on the boom. This means that the shoulder can be selectively repositioned at appropriate times so that it is placed in position for changing the chain only when needed and at other times can be appropriately positioned or stowed so as not to cause any possible obstruction during normal use of the trenching apparatus.

In an embodiment, in the inclined orientation, the ground engagement boom is at an angle of between 10 and 45 degrees to the body of the trencher.

According to a second aspect of the present invention, there is provided a method of putting a chain on to the ground engagement boom of a trencher, wherein the trencher comprises a body that is moveable on the ground surface and a ground engagement boom associated with the body, and lifting means arranged to control and configure the ground engagement boom so as to enter the ground from above and to configure the boom to an inclined orientation in which the boom extends at least partially over the body of the trencher, the method comprising, orienting the boom in the inclined orientation; engaging one of the ends of the chain with a cable of a winch provided on the body of the trencher; activating the winch to pull the chain onto the ground engagement boom.

In an embodiment, the ground engagement boom is movable in a substantially vertical plane.

There is provided a trenching method in which a winch for putting a chain onto a boom, or changing the chain on a chain cutting or mixing boom, is provided on the trenching apparatus (or body thereof) itself, and not on the boom itself. Positioning of the winch in the present system on the body of the machine or apparatus itself enables and ensures that a

chain can easily be changed on the ground engaging boom irrespective of the size of the ground engaging boom and the associated size and weight of the cutting chain itself.

In an embodiment, the cable is routed via a shoulder on the distal end of the ground engagement boom to enable substantially the entire length of the ground engagement boom to be surrounded by the chain.

The method can include moving e.g. slidably moving a shoulder or pulley mounted on the boom for directing the cable of the winch used when changing the chain on the boom. This means that the shoulder can be selectively repositioned at appropriate times so that it is placed in position for changing the chain only when needed and at other times can be appropriately positioned or stowed so as not to cause any possible obstruction during normal use of the trenching apparatus.

Brief Description of the Drawings

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings in which:

Figures 1 and 2 are a schematic views of a known trenching apparatus;

Figure 3 is a schematic view of component parts of a vertical chain cutting trencher;

Figure 4 is a schematic view of the trencher Figure 3, assembled prior to engagement of the ground engaging boom with the ground;

Figure 5 is a schematic view of the trencher in Figure 4 with the ground engaging boom at full depth in the ground;

Figure 6 is a schematic view of the trencher machine on a trailer arriving at a trenching site;

Figure 7 is a schematic view of the machine of Figure 6 with support legs extended;

Figure 8 is a schematic view of the machine of Figure 7 with support legs extended and feet lowered;

Figure 9 is a schematic view of the machine of Figure 8 with tracks provided on the machine;

Figure 9A is a schematic view of the machine of Figure 9, with the trailer removed;

Figure 10 is a schematic view of the machine of Figure 9A with the legs in a closed position;

Figure 11 is a schematic view of the machine of Figure 10 with hydraulic reels provided thereon;

Figure 12 is a view of the machine of Figure 11 with a protective chute provided thereon;

Figure 13 is a view of the machine of Figure 12, assembled with the ground engaging boom prior to engagement of the ground engaging boom with the ground and prior to connection of the boom to hydraulic lines;

Figure 14 is a view of the machine of Figure 13 with the ground engaging boom lowered for connection of chain drive services such as hydraulic lines;

Figure 14A is a view of the machine of Figure 14 with the ground engaging boom partly submerged, i.e. at an intermediate trenching depth;

Figure 15 is a view of the machine of Figure 14A with the ground engaging boom at full trenching depth;

Figure 16 is a detailed view of the machine including the ground engaging boom cradle;

Figure 17 is a schematic view of the machine showing the boom cradle open;

Figure 18 is a schematic view of the machine with the boom cradle open without a cutting boom assembled therein including a chute extension;

Figure 19 is a representation of the machine with a ground engaging boom in position but no cutting chain installed;

Figure 20 is a view of a close-up of the top of the ground engaging boom.

Figure 21 is a schematic view of a machine including an auxiliary power supply; and

Figure 22 is a view of a trenching machine including an auxiliary power supply unit.

Figures 1 and 2 show schematic views of a known trenching apparatus. It is a trench cutting apparatus as described in EP-A-0080802, for cutting a trench in rock.

Two crawler chassis 3 and 5 are coupled together by tie bars 7, the rear crawler 3 having a cutting boom 2 pivotally mounted at 6. The forward end of the boom 2 has a cutting boom 2 pivotally mounted at 6. The forward end of the boom 2 has a cutting rotor 7 driven in rotation about an axis transverse to the trench to be cut. The distal end of the boom 2 is coupled to the forward crawler 5 by a telescopic control arm 8 comprising a hydraulic ram and telescopically extending sleeves coupled to the boom 2 by a coupling 9. In operation the machine is positioned to straddle the line of the trench and the boom 2 is lowered into contact with the ground. The cutting head 7 is rotated while applying force by way of the hydraulic ram 8 to move the cutting head 7 on an arcuate path downwardly and to remove rock from the forward end of the trench. An endless chain conveyor 4 is positioned behind the cutting rotor 7 and the spoil is carried away. The boom 2 is then raised and the machine moved forward and the process is repeated.

Although the trenching apparatus described above works well, there is a need for a trenching apparatus that is able to cut a deeper trench. This has application in fields such as the building of trenches in riverbanks for example. Such trenches may be built for the purpose of the creation of water-impermeable barriers or for strengthening the structure of the ground, for example, by mixing earth from the trench region with cement, thereby forming a hardened vertical wall within the ground where the trench is formed. As used herein, the term trenching includes the use of ground engaging members both for cutting trenches in the ground and also for mixing of the earth or material within a trench as might be done for example where cement is mixed with soil to control various physical properties of the ground.

Accordingly as used herein, the term “ground engaging member” or “ground engaging boom” is to be understood as relating to a member that generally engages with the ground which could include either cutting or forming a trench within the ground or mixing cement or other mixing material such as bentonite, within a trench with the soil in the trench. Indeed considering these two specific examples, either could be referred to as “trenching” and in both cases a trench is formed.

Figure 3 shows a disassembled schematic view of a trenching apparatus for such purpose.

The apparatus includes a trenching machine 10 arranged to receive a ground engaging boom 12 which may be a cutting boom and importantly which can be inserted into the ground in a vertical orientation. Such a vertical cutting boom trenching machine has particular advantage in that the ground engaging boom can be inserted into the ground effectively within the footprint of the machine itself, i.e. without requiring space outside of the footprint for a cutting arc.

Vertical insertion typically means that the movement of the ground engaging boom is translationally downwards rather than, say pivoted but it need not require that the boom extends and enters the ground at precisely 90 degrees to the ground surface. Typically an angle of attack of the ground engaging boom, i.e. the angle that the longitudinal axis of the ground engaging boom makes to the surface of the ground, will be ±10% to the vertical. More preferably the angle of attack is ±5 degrees to the vertical and most preferably it is vertical.

In the examples shown, the ground engaging boom 12 includes a cutting chain 14 which has the function both of cutting a trench and, in this example, also due to the features and elements 16 on the chain providing a mixing function, for mixing an agent such as (but not limited to) cement that may be provided in the trench with the surrounding earth. As explained above such a process has the advantage in that a barrier of reduced porosity or water permeability can be created which in areas such as those close to river or canal banks is desired.

The trenching apparatus 10 includes tracks 18 and jack legs 20, which provide a significant technical function to this specific type of trenching machine in accordance with a disclosed embodiment, and as will be described in greater detail below.

A protective chute 22 is provided arranged, in use, and as will be described in greater detail below, to couple with a chute section 24 provided as part of a boom cradle 26. The protection chute 22 may also be used for other functions such as washing the ground engaging boom when it is not engaged with the ground.

An engine and control module 28 is provided in which a driver or operator may sit to control the apparatus 10 in use.

Hydraulic reels 30 are provided which are arranged on the main body 34 of the machine 10, arranged to be driven by a main hydraulic power supply (not shown) within the main body 34. The main hydraulic power supply is also arranged to provide power to drive the movement of the ground engaging boom 12 by powering a pinion 40 (see Figure 18), to be described below. The main hydraulic power supply may typically be a hydraulic pump having an inlet and an outlet and being arranged and configured to pump hydraulic fluid to provide power as required. Any suitable type of hydraulic pump can be used, as will be known to the skilled person.

The hydraulic reels 30 are provided, arranged to receive hydraulic fluid from the main hydraulic power supply and thereby to drive the cutting chain 14. When the machine is assembled and operating in trenching mode, the hydraulic lines 30 are coupled to an upper end 36 of the ground engaging boom 12, as will be descried in greater detail below. The ground engaging boom 12 is provided with an integrated rack 38 arranged in use to interact and be driven by the pinion 40 (see Figure 18). The pinion 40 is driven, in most cases by the main hydraulic power supply too and thereby controls the vertical position of the ground engaging boom 12 with respect to the cradle 26, and hence to the ground too.

Figure 4 shows a schematic view of the trenching machine 10 arranged in position ready for operation. In the example of Figure 4, the ground engaging boom 12 is ready for engagement with the earth, but has not yet been driven into an engaged position. Hydraulic power is provided which drives the ground engaging boom down into the ground. As can be seen, the elements 14, such as teeth, at the lower end of the cutting boom 12 are close to the ground, but have not yet broken the surface. The angle of attack of the ground engaging boom 12 is almost exactly 90 degrees in the example shown. In addition due to the manner in which the rack and pinion mechanism forming part of the cradle 26 operates, the driving force will be in line with the boom and thus vertically downwards.

The height of the boom 12 can be as required for the particular trench cutting and mixing job but preferably is at least 10 metres long and more preferably between 15 and 20 metres long. In particular, trenching operations, it is desired that the boom is at least 15 metres long. In such cases, the mass of the boom, including the cutting chain, in use, could be up to 30,000KG. A plurality of stabilising legs 20 are provided which function to stabilise the machine itself while, or during, the lowering of the cutting or mixing boom 12 into the surface of the soil takes place.

It has been recognised that in the example of vertical or near vertical impact trenching machines such as that shown in Figures 3 and 4, a stability providing mechanism flexibly or selectively reconfigurably connected to the housing 34 of the machine 10 provides a convenient and advantageous mechanism for ensuring stability of the machine during the lowering of the trenching/mixing boom 12 into the surface of the soil. It has been recognised that although the centre of mass of the machine will still be positioned above the footprint of the machine the height of the boom itself can generate a lack of stability, particularly if, say the environment is one in which high winds can be present.

Although in known systems there is no suggestion or reason why stability providing legs should be included (indeed it has previously been thought that the boom itself when engaged with the ground is a source of stability), it has now been recognised that they can provide a significant advantage in terms of accounting for atmospheric conditions and their effect on the machine's stability.

Referring to Figures 7 to 9 and 9A, the stability legs 20 comprise a proximal end 42 coupled to the machine and a distal end 44 from which a vertically downwardly depending longitudinal support member 46 is arranged to extend. The legs 20 are selectively reconfigurable such that they can be folded (or telescopically collapsed) into close alignment with the machine 10 as shown in, say, Figures 11 or 12, or provided in an extended configuration as shown in any of, say, Figures 7 to 9 and 9A.

Feet 48 are provided as separate and connectable components which are provided with an engagement region 50 for connection to the distal end of the downwardly depending longitudinal support member 46. In this examples, the downwardly depending longitudinal support members 46 are arranged to extend telescopically from an upper region 49. As will be explained below, the legs 20 are used during the process of erection of the ground engaging boom 12 and lowering of the boom into the surface of the ground. Once the boom 12 has been lowered to a desired depth, the requirement for the extension of the legs 20 into the extended configuration as shown in Figure 7 is reduced. The boom 12 inserted into the ground, itself provides a stabilising function and therefore the legs 20 can be collapsed or retracted or removed.

As explained above, in one configuration, the legs may be pivotably connected to the machine 10 at the proximal end 42. In an alternative embodiment, they may be removably and fixedly connected. In the example of Figure 7, the shaping of the legs 20 can be seen. In particular, as will be appreciated, there is an overlap region along the central longitudinal

axis of the machine 10, wherein the legs in each of the front and rear pairs overlap with each other. Looking again at Figure 9, at the rear of the machine 10 there is a first pair of legs 52 and at the front of the machine there is a forward pair of legs 54.

Each of the legs has a length that extends across the width of the body of the machine such that looking at the first pair of legs 52 it can be seen that the longitudinal body of the leg 56 extends under the machine and to the other transverse side. Still looking at the rear pair of legs 52, the end 58 of the second leg of the pair (the foot of which cannot be seen in Figure 9) can be seen extending towards the opposite transverse side of the machine 10. Thus, there is overlap of the pair of legs in the region of the body of the machine 10 as indicated by the arrow A. This ensures that the legs, when extended and engaged with the ground, through their interaction with the centre of mass of the body of the machine 10, provides significant stability to it.

In one example and in the specific example of Figures 7 to 9 and 9A, due to the extension of the legs across the entire width of the body, the legs may be formed of two telescopic sections such that there is an outer telescopic section 60 and an inner telescopic section 62 which, when in a closed configuration, will be positioned substantially within the length of the first telescopic section 60.

The use of such telescopically extending legs 20 ensures that stability can be provided to the machine as a whole during insertion or lowering of the boom 12 into a trench for cutting or mixing. Typically whenever the ground engaging boom 12 is not engaged with the ground, i.e. not submerged below ground surface, the legs will be extended so as to provide stability to the trenching apparatus.

Referring again to Figure 3, the protective chute 22 will now be described. The machine 10 includes an integrated protective chute 22 which has a generally U-shaped cross-section. The position and configuration of the chute on the machine is so as to be able to prevent fouling of the machine body 34 during the forward folding and transporting of the ground engaging boom or cutting mechanism. Referring to, say, Figures 14 and 16, the chute 22 can be seen coupled to the body 34 of the machine 10. Coupling arms 66 are provided to support the chute 22 along its longitudinal extension.

As can be seen, the cradle 26 is included with a chute extension 24 which, when the cradle 26 is in the upwards (folded) position as shown in Figure 14 for transporting of the ground engaging boom 12, forms a continuous channel with the fixed chute 22. The dimensions of

the chute 22 and the chute section 24 forming part of or associated with the cradle 26, are such that the end 68 of the chute 22 will fit within the dimensions of the end 70 of the chute section 24. Typically, the general dimensions will be substantially the same, but the end 70 of the chute section 24 may have a slightly enlarged width so as to accommodate the cross-section of the end 68 of the chute 22.

Looking again at Figure 14, it can be seen that the chute and chute section 24 when assembled, form a continuous channel within which at least some of the cutting elements 14 of the chain are positioned. This assembly is particularly advantageous since it means that the chain 14 and its cutting elements 16 can be easily washed by water or other washing fluid introduced to flow down the chute 22 under the force of gravity and/or from pressurised fluid flow from an associated pump. The configuration of the assembled chute 22 and chute section 24 ensures that washed or dropped cutting material from the chain 14 is directed away from the machine and to a suitable place. Typically, the water and the washings from the chain 14 may be directed into the trench that has just been cut or indeed onto the ground in a region where a trench will shortly be cut. In either case, the positioning of the washings is advantageous in that it is away from the machine 10 itself and importantly the cuttings or droppings from the chain do not fall onto the machine.

In a preferred example, it could be that the chain is actually driven when in the configuration as shown in Figure 16 at the same time as a pressurised flow or jet of water is directed down the down the chute and chute extension 24 such as to ensure that all cutting elements on the chain 14 of the boom 12 are washed. This means for washing the chain of a chain cutter is advantageous as it is conveniently performed by the machine 10 itself and at least partially within the footprint of the machine itself.

Referring again to Figure 3, a winch 80 is shown mounted on the machine 10. The winch 80 is configured to function as a source of force to pull a chain onto the ground engaging boom when required. In known systems, such a winch may typically be provided on the ground engaging boom itself. It has been recognised that this may be disadvantageous given the weight of the ground engaging boom. The positioning of the winch in the present system is on the machine 10 itself. As will be described below, this ensures that a chain can easily be changed on the ground engaging boom irrespective of the size of the ground engaging boom and the associated size and weight of the cutting chain itself.

Operation and functioning of the cradle 26 will now be described. Looking at Figures 3, 5, 14 and 16 to 18, it can be seen that a plurality of hydraulic drive cylinders 82 are provided.

The configuration of the hydraulic drive cylinders 82 can be seen clearly in Figure 5 which shows the hydraulic drives 82 having a pivoted connection 84 to a rear wall 86 of the cradle 26. The cradle also has a central pivoted coupling 88 to a fixed section of the machine 10. The cradle 26 is usually, during mixing/ground engagement, arranged with the hydraulic hydraulic drive cylinders 82 extended such that the back surface 86 is generally vertical. This is a configuration shown in, say, Figure 3.

To change the cutting chain on the ground engaging boom, the ground engaging boom is first lifted out of the ground and the hydraulic arms 82 are contracted. This causes the back surface 86 of the cradle to pivot about pivot point 88 such that the ground engaging boom will then be rested within the chute 22, as described above. In this configuration, the winch 80 can be activated as described with reference to Figure 19. The winch 80 is coupled to a longitudinal coupling member such as a rope or wire cable 90.

As can be seen in Figure 19, the cable 90 extends back and forth around a shoulder 92 including a pulley wheel 94 around which the cable 90 is arranged to go. The cable 90 then extends backwards to the top of the cutting boom 36 and then forwards again to its end 96. The end 96 of the rope or cable 90 may then be coupled to a replacement chain, the first link 98 of which is visible in Figure 19. Replacing the cutting chain on the boom is then simply achieved by activating the winch 80 to wind up the rope 90 and thereby pull the chain 98 along the length of the ground engaging boom so as to entirely surround the both longitudinal sides of the boom and enable the chain to be fixed to it.

Once the link 98 reaches the position of the wheel 94 and shoulder 92, the rope 90 can be disconnected form the new chain 98 and the chain closed in known ways. This for example could involve pulling round the then distal (free) end of the chain that has not yet been pulled onto the boom and connected to the end of the chain that has been pulled by the rope or cable 90.

Looking still at Figure 19, a tensioning mechanism is provided at the top end 36 of the boom 12. The tensioning mechanism 100 can be seen more clearly in Figure 20. The tensioning mechanism includes a pivot arm 102 pivotally connected to the top end of the cutting boom via a pivot 104. A pinion 106 is provided for engagement with the chain 14. In use, the chain will pass between the pinion 106 and bracket 108 which acts as a restraining or containing mechanism for the chain on the tensioning system 100. The arm 102 is driven via a hydraulic drive system including cylinders 110 which is pivotally mounted to a fixed pivot 112 on the top end of the boom and a fixed pivot 114 at the distal end of the arm 102 of

the tensioning mechanism 100. It will be appreciated that by extension of the hydraulic system 110, the arm 102 will be pivoted about pivot 104 relative to the boom, thereby tensioning the chain 14 around the cutting boom 12.

The positioning of the chain adjustment mechanism on the ground engaging boom itself and importantly at the upper end of the boom, provides a number of significant advantages. First, the tensioning mechanism is remote from the lower end of the ground engaging boom 12 which will be interacting on a more regular basis with the earth formation being trenched. Secondly, this will ensure that the tensioning mechanism is kept away from the section of the boom that is likely to be most engaged with the mixing agent, such as cement, when used as a mixing mechanism. It is known and conventional to provide such tensioning mechanisms at the distal end of a ground engaging boom but it has been recognised that by providing the tensioning mechanism at the top end of the cutting boom the risk from the mixing agent being used setting and thereby possibly rendering the tensioning mechanism ineffective, is significantly reduced.

Finally, referring to the cradle 26, reference is made to Figure 17. The cradle 26 has a number of sections and the cradle can be opened or closed to enable replacement and/or orientation of the ground engaging boom 12. The cradle in the example of Figure 17 includes a pivoted door section 41 hingedly mounted via hinges 43 to a rear section 45. A pinion 40 is provided which in use is arranged to mesh with rack 38 formed of a plurality of teeth on the ground engaging boom 12. The pinion 40 is preferably driven by hydraulic power from main trencher body 34 that may be derived from hydraulic power lines 15 (seen in Figure 4, but not shown in Figure 17). Thus by the interaction of the pinion 40 and rack 38 it can be simply and reliably ensured that the direction of drive of the ground engaging boom is always aligned with the longitudinal axis of the ground engaging boom 12.

Figure 18 shows the cradle 26 open and with the ground engaging boom 12 removed. Thus the chute section 24 can be seen with flared ends 70 and 71. The chute section is preferably provided as a fixed or integrated part of the cradle and ensures that a continuous channel can be formed with the chute 22 when the cradle is in a raised (folded) position, such as that shown in Figure 14.

The process of use of the machine described above will now be described. Initially, as shown in Figure 6, the machine 10 may be provided on a trailer 120 for moving to an area where trenching is to be performed. The legs 20 are stowed so as not to generate unnecessary width of the machine during transport. Next, referring to Figure 7, the legs 20

are extended and feet 48 arranged in position to receive and engage with the legs. Any suitable form of fixing can be used to lock the feet 48 temporarily to the legs 20. With the machine still on the trailer, the legs 20 are jacked down such as to engage with the feet 48 as shown in Figure 8. With the machine still on the trailer, tracks are coupled to the machine as shown in Figure 9. With the legs and feet coupled as shown in Figure 9A, the trailer can be removed leaving the machine 10 supported by the legs and feet 48.

The machine is then lowered onto the ground as seen in Figure 10 and the legs 20 may be pulled back into the body of the machine as described above. Figure 10 shows clearly the tracks now supporting the machine on the ground with the feet 48 lifted such that they are no longer in contact with the ground.

Looking at Figure 11, the hydraulic reels 30 are positioned on the machine 10 and the cradle 26 is coupled to the rear of the machine. Next, as shown in Figure 12, the chute 22 is fitted to the machine 10. The chute section 24 is already fixed to the cradle 26.

Next, the mixing boom 12 is engaged with the cradle 26 as shown in Figure 13. A crane may be used to initially lift the ground engaging boom 12 into position for engagement with the cradle 26. It is noted that the legs 20 are extended at this stage, thereby providing stability to the machine during the assembly of the machine with the boom 12 and prior to the boom actually engaging the ground and thereby providing stability of its own.

The machine or rather the ground engaging boom is then lowered as shown in Figure 14 by tilting back of the cradle 26. This is achieved as described above by operation of the hydraulic controls via hydraulic cylinders 82 and the various pivot configurations provided on the back wall of the cradle. In this lowered position, connection of the chain drive services, via tubes (hoses) from the hydraulic reels 30 is possible.

As shown in Figure 3, at this stage, the legs 20 are extended in preparation for the fitting of the ground engaging boom 12, because this is the point in the process at which the centre of gravity of the machine 10 is highest due to the vertical extent of the ground engaging boom 12 once there has been initial engagement in the cradle 26 (as shown in Figure 13).

Once this process is achieved the ground engaging boom 12 is now ready for folding down, (i.e. tilting backwards into the configuration shown in Figure 14) for connection of the hydraulic supply lines 30. The hydraulic supply lines 30 are coupled to the top of the boom for driving the cutting and mixing chain on the ground engaging boom. When the boom is

then rotated back to the vertical configuration, as shown in Figure 4, the ground engaging boom 12 is now ready for engagement with the ground. The legs 20 provide stability in this configuration.

As shown in Figure 14A, the trenching operation has commenced with the boom driven down by use of the rack and pinion described above provided within the cradle 26 and on the boom itself. In the configuration of Figure 14A the ground engaging boom is partially submerged within the ground. The boom is submerged to a desired depth which will produce a desired depth of trench. The legs 20 are raised and brought into the body of the machine 10 as described above since they are not needed at this stage for stability. With the chain operated by the chain drive services the tracks of the machine can be controlled to control the formation of and the direction of the trench.

As shown in Figure 15, the machine trenching is now at full depth with the boom deep underground and thereby providing an anchor and stability to the machine 10 in operation.

Thus, the machine is able to operate with an extended boom whilst not risking any lack of stability which could be catastrophic. This is particularly the case in high-wind situations, which may be encountered in some operating environments of trenching machines of this nature. In particular, when the machines are used in a river bank location, and winds occur, which is likely, the risk of damage to the ground engaging boom and even the machine 10 itself is significant.

Figures 21 and 22 are, views of a machine 75 including an auxiliary power supply 74. Figure 21 is a simplified schematic view. In some situations, it is possible that the main hydraulic power supply provided as part of the machine 75 fails. This could occur for a number of reasons such as, for example, the supply runs out of fuel or one of the supply hoses becomes damaged in use or breaks off from the machine. In this situation, which may generally be thought of as failure of the main hydraulic power supply, there is a risk to the machine and in particular the ground engaging boom 12 which will typically be engaged with the ground if the main hydraulic power supply is in operation providing power to drive the pinion as described above. In such a situation, when the ground engaging boom is being used for, for example, mixing of a mixing fluid with soil, the mixing fluid in the case of cement could set thereby fixing the ground engaging boom in the trench that has been cut and filled with mixing agent such as (but not limited to) cement.

Typically, in the event of such a main power supply failure, it might be up to three days until a replacement can be obtained or indeed engineers can be provided to fix the power failure on the machine 75. In accordance with one aspect of the present system, an auxiliary power supply 74 is provided which can be used as a "hot stab" unit, i.e. which is then able to immediately replace the main hydraulic power supply of the machine and provide the required power to remove the ground engaging boom 12 from its engaged position. The boom can then be extracted using the existing rack and pinion mechanism, described above, which is powered by the auxiliary power unit 74.

By ensuring that the ground engaging boom 12 can be quickly and reliably removed from the ground in the event of main power supply failure, this ensures that the ground engaging boom will not become set in the ground due to the delay that would otherwise be encountered.

The auxiliary power supply unit 74 may be referred to as a hot stab unit since it will typically include a pair of hydraulic supply lines 76 which are connected to hydraulic inputs in a power circuit of the machine to thereby drive the pinion and extract the ground engaging boom from its engaged position.

Looking at Figure 21, which shows schematically, the arrangement of an auxiliary power supply unit, it can be seen that a lift motor 79 arranged in normal use to receive power from supply lines 30 is provided with sockets 81 to which the connectors 83 of the auxiliary supply unit can be connected. Valves 85 on the supply lines 30 are closed and the lift motor 79 is instead powered by the hydraulic pump and supply unit via inputs 81. The lift motor may be the motor that in use powers the pinion 40.

Looking at Figure 22, the auxiliary power supply unit 74 is preferably provided as a separate unit. It may be provided entirely independently, but preferably is arranged coupled to the machine 75. The machine 75 includes input sockets 81 arranged in normal use to be provided with power from the existing hydraulic supply lines of the machine but, in the event of main power supply failure, connectors 87 provided at the distal ends of the supply line 76 maybe coupled to the inputs 81 to power the pinion and thereby, via interaction with the rack on the ground engaging boom 12, cause the boom to be lifted out of the ground.

Embodiments of the present invention have been described with particular reference to the examples illustrated. However, it will be appreciated that variations and modifications may be made to the examples described within the scope of the present invention.

Claims

1. A trenching apparatus, comprising:

a body moveable on the ground surface,

a ground engagement boom associated with the body, wherein the ground engagement boom comprises a chain for interacting with earth in use;

lifting means arranged to control and configure the ground engagement boom so as to enter the ground and to configure the boom to an inclined orientation in which the boom extends at least partially over the body;

a winch provided on the body to engage with the chain of the ground engagement boom when in the inclined orientation.

2. Apparatus according to claim 1 in which the ground engagement boom is a cutting boom for cutting earthen material from the end surface of the trench.

3. Apparatus according to claim 1 or 2, in which the ground engagement boom is a mixing boom for mixing agent such as (but not limited to) cement with earth within the trench.

5. Apparatus according to any of claims 1 to 4, in which the longitudinal length of the ground engagement boom is between 10 and 20 metres.

6. Apparatus according to claim 5, in which the ground engagement boom weighs between 10 and 20 tonnes, and preferably weighs up to 15 tonnes.

7. Apparatus according to any of claims 1 to 6, comprising a protection chute provided on the body of the trencher to protect the body from material that falls from the boom and to support the boom in the inclined orientation.

8. Apparatus according to any of claims 1 to 7, in which comprises a spool with a cable having an end connector for engagement with the end of a replacement chain to be put on the ground engagement boom when in the inclined orientation.

9. Apparatus according to claim 8, in which the cable is routed via a shoulder on the distal end of the ground engagement boom to enable substantially the entire length of the ground engagement boom to be surrounded by the replacement chain.

10. Apparatus according to claim 9, in which the shoulder comprises a pulley.

11. Apparatus according to claim 8 or 9, in which the shoulder is slidably mounted on the body of the boom so that it can be moved from the top end to the distal end at which end it can be used to change the chain on the boom.

12. Apparatus according to any of claims 1 to 10, in which in the inclined orientation, the ground engagement boom is at an angle of between 10 and 45 degrees to the body of the trencher.

13. A method of putting a chain on to the ground engagement boom of a trencher, wherein the trencher comprises a body that is moveable on the ground surface and a ground engagement boom associated with the body, the ground engagement boom being movable in a substantially vertical plane, and lifting means arranged to control and configure the ground engagement boom so as to enter the ground from above and to configure the boom to an inclined orientation in which the boom extends at least partially over the body of the trencher, the method comprising, orienting the boom in the inclined orientation;
engaging one of the ends of the chain with a cable of a winch provided on the body of the trencher;
activating the winch to pull the chain onto the ground engagement boom.

14. A method according to claim 13, in which the cable is routed via a shoulder on the distal end of the ground engagement boom to enable substantially the entire length of the ground engagement boom to be surrounded by the chain.

Intellectual Property Office

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Claims searched:	1-14	**Date of search:**	11 March 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-14	FR 1364033 A (AUXITRA) See figures 1, 3 and 4.
X	1-14	JP 2001248181 A (KONDO) See figures 1-3.
X	1-14	GB 1277007 A (WILSON) See figure 1 and 3.
X	1-14	CN 1438392 A (QIAN) See figures 15a-15f.
X	1-14	CN 101619573 A (XIAOWEN et al.) See figures 1 and 2.

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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E02F

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

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International Classification:

Subclass	Subgroup	Valid From
E02F	0005/06	01/01/2006
E02F	0003/08	01/01/2006
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